MIAMI UNIVERSITY

Institute for the Environment & Sustainability

Professional Service Project

Final Report

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HUESTON WOODS STATE PARK BIKEWAY FEASIBILITY STUDY

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Hueston Woods State Park
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EXECUTIVE SUMMARY

First-year graduate students in the Institute for the Environment and Sustainability at Miami University worked with Hueston Woods State Park in Butler County, Ohio to explore the feasibility of adding a bikeway at the park. The park offers a wide variety of amenities and attractions, but doesn't offer a path for pedestrians and bicyclists to travel along the Main Loop Road from one end of the park to the other. After exploring the associated environmental regulations, public opinions, related barriers, engineering concerns and financial costs, the team recommended that the park not construct a bikeway, but instead add shared lanes signage and a bicycle education program. This alternative has minimal cost, can be implemented more immediately, and causes little environmental impact. However, if Main Loop Road is reconstructed, the project team recommends incorporating a paved shoulder into the roadway. Some additional recommendations include exploring bikeway options within the park but away from Main Loop Road, considering whether connection to other pathways outside the park are possible, and gathering further public input to determine if a new pathway is desired.

ACKNOWLEDGEMENTS

The team is grateful for the guidance provided by Suzanne Zazycki, M.En., J.D., Outreach Coordinator for the Institute for the Environment and Sustainability.

The following individuals have contributed to this professional service project:

Hueston Woods State Park

Amanda Dalton, Natural Resources Specialist

Mark Lockhart, Park Manager

Chad Smith, Interpretive Services Manager

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1.0 INTRODUCTION

This report summarizes the research conducted by a team of Master's students from Miami University's Institute for the Environment and Sustainability (hereafter "project team" and "team"). The research pertains to the feasibility of constructing a bicycle and pedestrian path along Main Loop Road at Hueston Woods State Park (HWSP). Currently bicyclists and pedestrians must travel in the same lane as vehicle traffic because there is no path and little shoulder. This report describes the project team's research plan, methodology, path alternatives and recommendations. The team conducted this research to provide HWSP with a comprehensive report describing the economic, environmental, and engineering issues that would likely arise if HWSP were to construct a path for pedestrians and bicyclists around Main Loop Road. The research was conducted from August 2012 – May 2013 to fulfill the requirements for a course entitled Professional Service Projects (IES 610).

1.1 BACKGROUND

Hueston Woods State Park (HWSP), located in Preble and Butler Counties in southwest Ohio (Figure 1), is a destination spot for many tourists seeking to connect with nature and view beautiful natural landscapes. With almost 3,000 acres of land, HWSP attracts 2.5 million visitors a year making it one of the top five visited state parks in Ohio (Ohio Department of Natural Resources 2012, 1). Visitors to HWSP can enjoy a wide variety of recreational activities, such as boating or fishing on the 625-acre Acton Lake, hiking, mountain biking, horseback riding and golf. Other attractions include a resort lodge, a campground, rental cabins and the Hueston Woods State Nature Preserve (Figure 2). The preserve, which contains one of the few remaining old growth beech and maple forests in Ohio, is designated as a National Natural Landmark by the National Park Service. An annual Maple Syrup Festival and Pioneer Farm Museum attract many visitors to the park, as does its notable Raptor Rehabilitation Center, where birds of prey have been nursed and released for more than 30 years. To accommodate visitors, HWSP contains about 16 miles of hiking trails, 12 miles of mountain biking trails and 18 miles of horse trails (Ohio Department of Natural Resources 2012, 1).

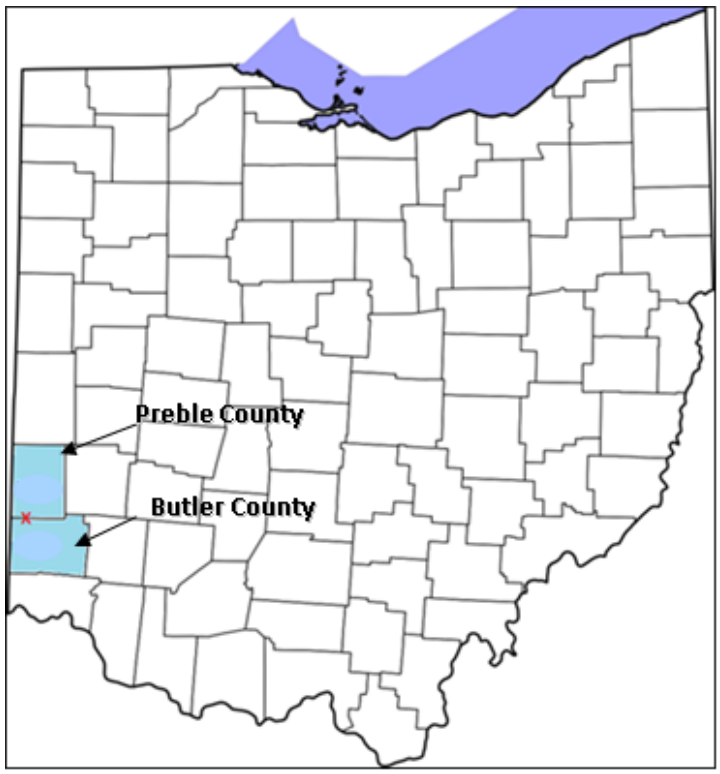


FIGURE 1 LOCATION OF HWSP
(Map adapted from radioreference.com 2013)

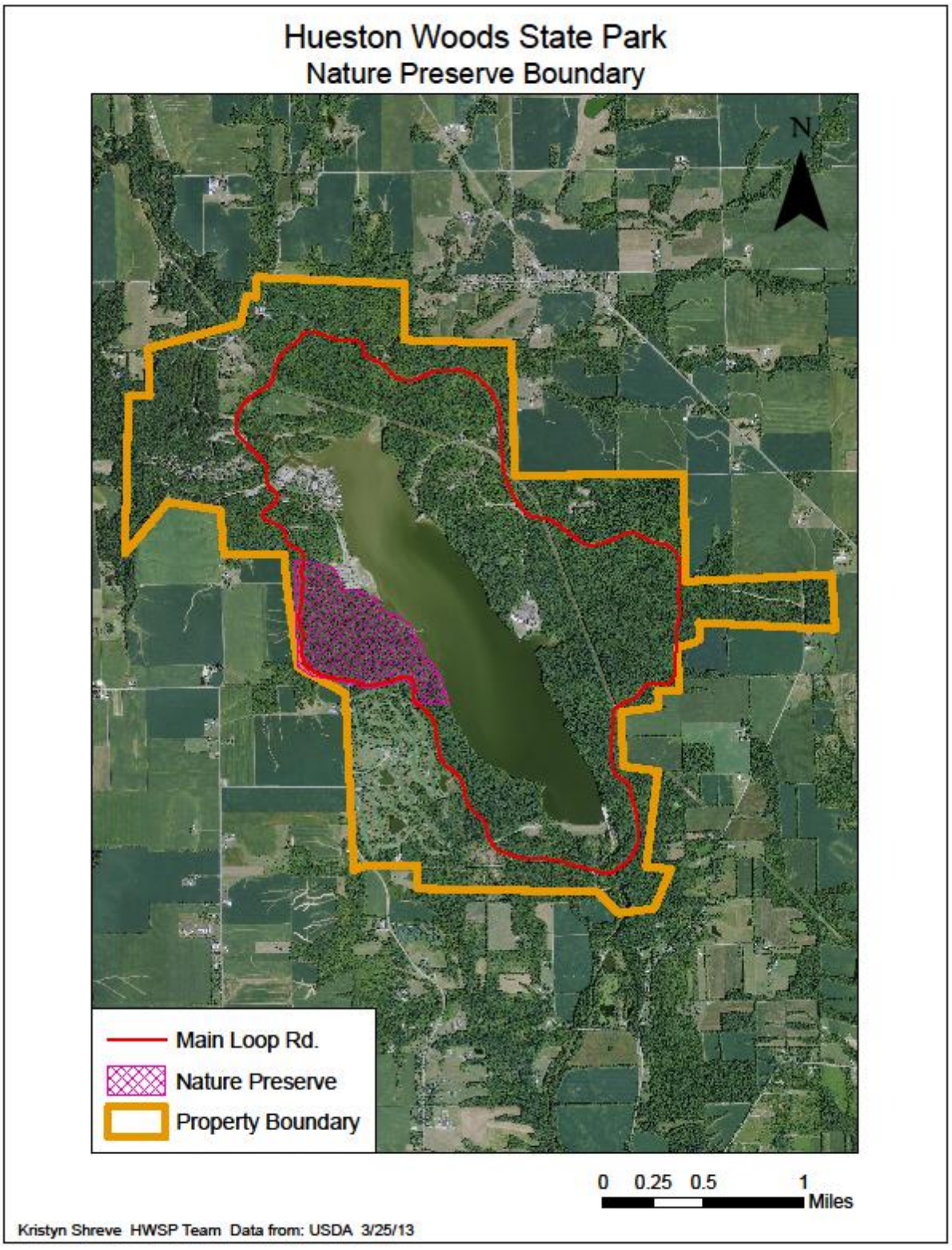


FIGURE 2 HWSP BOUNDARY, INCLUDING THE NATURE PRESERVE AND MAIN LOOP ROAD

As seen in Figure 2, Acton Lake is located in the center of the park and is surrounded by the 8.6 mile Main Loop Road. Because of this configuration visitors must travel along Main Loop Road to get from one side of the park to the other. Currently, bicyclists and pedestrians must travel with traffic on the roadway, because there is little to no shoulder (Figure 3). While park staff reports no bicycle or pedestrian accidents or injuries on Main Loop Road, they were interested in exploring whether an adjacent bikeway would make the road safer and more enjoyable for all park visitors.

FIGURE 3 BICYCLISTS AT HWSP ON MAIN LOOP ROAD (Grimm 2009)

1.2 PROJECT DESCRIPTION

PROBLEM: HWSP is dedicated to providing a safe and exceptional outdoor recreational experience where visitors can enjoy nature. However, a pathway for bicyclists and pedestrians to travel along Main Loop Road to all areas of the park does not currently exist.

GOAL: Provide HWSP with recommendations for a safe, cost efficient and environmentally responsible path along Main Loop Road.

OBJECTIVE 1: Determine the obstacles that exist for constructing a path along the road. For trail projects, these are referred to as "trailblocks," which is anything that has the potential to hamper the development of the project. These may include the regulatory guidelines and environmental policies associated with the state park and nature preserve, and the physical obstacles that must be removed prior to construction.

OBJECTIVE 2: Gather input from stakeholders, experts, and HWSP employees. In addition, gather input from HWSP visitors through an exploratory survey to analyze public opinion on safety while traveling along Main Loop Road.

OBJECTIVE 3: Create Geographic Information System (GIS) maps to illustrate the locations of physical obstacles and high risk areas along Main Loop Road, and develop visuals of the recommended path alternatives. (Appendix A explains the process the project team used to create GIS maps).

OBJECTIVE 4: Develop alternative bikeway designs and recommendations including cost estimates, optional bikeway features, signage, and education materials.

BOUNDARIES:

PHYSICAL: The goal of this project was to explore a means of providing a safe bike and pedestrian path along Main Loop Road in HWSP. Therefore, the research was focused within the physical boundaries of the park. However, the team also researched other bikeway plans in the region for potential connections that would impact HWSP.

STAKEHOLDER INPUT: Stakeholder input was sought from HWSP employees and a representative from Ohio Department of Natural Resources Division of Engineering through regular email communications and a series of meetings. Input from the general public was sought through an exploratory survey posted on the HWSP Facebook site. Because HWSP does not currently have plans or funding to construct a bikeway, the survey was designed to gather preliminary data about perceptions of safety while traveling through the park. The survey questions were carefully crafted to ensure that the public was not misled to believe that a bikeway was being planned.

FEASIBILITY STUDY COSTS: Based on in-kind contributions of services and goods, it is estimated that this feasibility study would have cost more than $19,000. The budget can be found in Appendix B.

TIME: This research project was conducted within the confines of a two-semester course August 2012 – May 2013.

1.3 Methodology

To identify the possible path options for Main Loop Road, the project team first determined the features of HWSP, including its attractions, layout and recreational usages. In addition, the team met with Chad Smith, the park's Interpretive Services Manager, to understand the park's structure, operations and long-term vision.

The team reviewed feasibility studies from other bikeway projects, such as the Mahican-Mohawk Bike Trail Feasibility Study (Fletcher et al. 2002), the Feasibility Study for the Miami2Miami Connection (Barge et al. 2002) and the Burlington Bike Path Improvement Feasibility Study (Burlington, VT Public Works 2009). Identifying these studies and bikeways allowed the team to determine the necessary components for the project. These studies led the team to various handbooks and regulatory resources that establish the basic parameters for a bikeway. These sources include the Ohio Department of Transportation (ODOT), the Highway Capacity Manual, the Ohio Manual of Uniform Traffic Control Devices, and the American Association of State Highway and Transportation Official's "Guidelines for Bicycle Facilities" (further referred to as the AASHTO Manual), which was the main source for regulations. Together, these sources allowed the team to compile the pertinent restrictions for the client, determine the path alternatives and develop a recommendation.

The bikeway feasibility studies also helped the team recognize the importance of identifying any "trailblocks" that could impede bikeway construction. Trailblocks are anything that has the potential to hamper the development of the project (Barge et al. 2002). These include the physical obstacles that may need to be removed

prior to construction, the environmental regulations pertaining to construction on state parks and nature preserves, and roadway requirements from ODOT.

In addition to gathering general information about bikeway design and construction, the team sought to understand the specific needs at HWSP. Those who contributed to the compilation of data provided in this report include park visitors, the park's manager, the park's social media contact, a representative from ODOT's Division of Engineering, and the client representatives Chad Smith and Mark Lockhart. In addition to these stakeholders, relevant experts were contacted to ensure credible information. These experts include Scott Vincent, an intern for HWSP and Miami student who assisted with GIS work; Travis Drury and Matt Hallett, IES students who assisted with GIS data; Heather Bowden, ODOT's bike/pedestrian planner who aided the team in sorting through roadway regulations; and Devin Schenk and Dr. Vincent Hand, professors at Miami University who furthered the team's knowledge of environmental laws.

In addition to this report, other deliverables were created to illustrate several facets of the project. These include a poster of the project analysis (Appendix C), GIS maps which depict the park boundaries and obstacles (Figures 2,4,6,8), and photos that illustrate the bikeway alternatives (Appendix P).

Together, the trailblocks research (section 2.0), which includes information about physical trailblocks, legal trailblocks, and social trailblocks, and the maps and visuals, allowed the project team to fully determine the alternative bikeways (section 3.0) that are relevant and possible at HWSP. To supplement the analysis of these alternatives, preliminary cost estimates were determined, and recommendations were chosen (section 4.0).

2.0 TRAILBLOCKS

A trailblock is any object, law or person that obstructs or denies the development of a bikeway alternative, a segment of the bikeway, or even discontinues the entire bikeway project (Barge et al. 2002). The project team has identified multiple trailblocks along Main Loop Road. These include physical trailblocks (utility poles, junction boxes, telephone cable boxes, guy-wires, signage, bridges, culverts, and steep slopes), legal trailblocks (laws and regulations) and social trailblocks (public input).

2.1 PHYSICAL TRAILBLOCKS

The project team mapped the occurrence and distribution of the physical trailblocks along Main Loop Road (Figure 4). From this map, the team determined areas where bikeway implementation may be difficult. Depending on the bikeway alternative, some of these objects may need to be moved. Common road signs, such as speed signs and stop signs, can be moved by park staff and were not counted as trailblocks.

There are 37 physical trailblocks occurring along Main Loop Road. Table 1 shows the breakdown in the occurrence of each type of physical trailblock. The project team assessed the placement of these physical trailblocks. Twenty seven of the physical trailblocks are found on the outside of the loop and only 10 are located on the inside of the road. The bridge and culverts affect both the inside and outside of the road.

TABLE 1 PHYSICAL TRAILBLOCKS

Physical Trailblock Name	Frequency along Main Loop Road
Bridge	1
Culvert	4
Junction Box	10
Sign	3
Telephone Cable Box	1
Utility Pole	16
Guy-wires	2

According to Mike Murray, Manager of Operations at Butler Rural Electric Cooperative, Inc, utility poles and junction boxes must be at least 10 feet from the shoulder of the road or bikeway. Currently, the utility poles and junction boxes are approximately 12 feet away from the road. Therefore, if the road is expanded more than 2 feet from its current location, these poles and junction boxes would need to be moved further from the road. Mr. Murray indicated that it would cost approximately $10,000 to move each electrical pole, and approximately $6,000 to move each junction box.

Some of the physical trailblocks, such as the bridges and culverts, cannot be moved without considerable reconstruction. Therefore, the project team considered the physical trailblocks to be a major factor when developing and evaluating bikeway alternatives. Because these trailblocks cannot be easily moved, one could use signs to alert the riders to upcoming obstacles. Appendix D provides a table of optional road hazard signs that could be utilized.

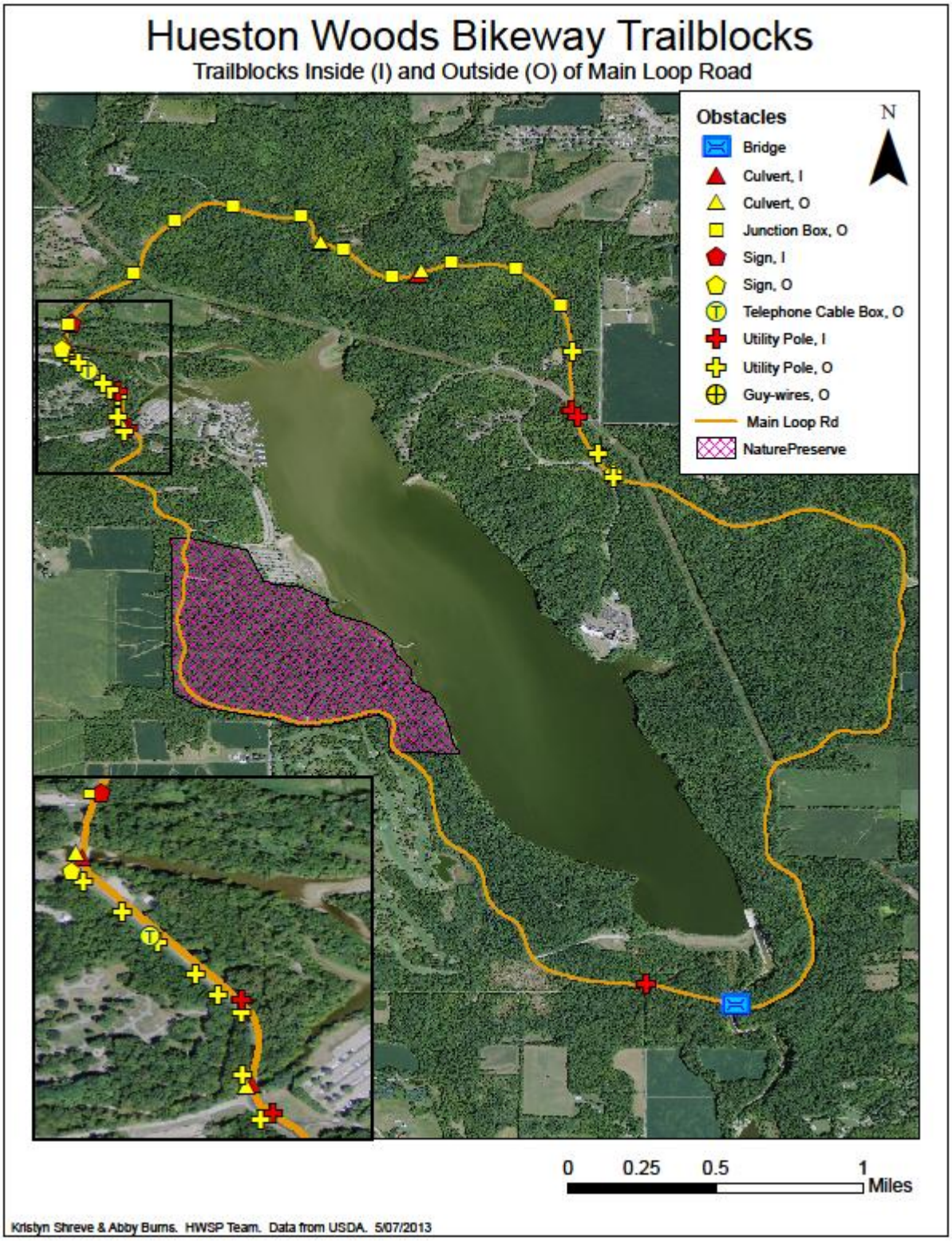


FIGURE 4 LOCATIONS OF PHYSICAL TRAILBLOCKS ALONG MAIN LOOP ROAD AT HWSP

The last group of physical trailblocks includes the steep slopes on either side of the road and the gradient of the road itself. Some slopes along the side of the road are so steep that they substantially hinder the construction of a bikeway (Figure 5). In these areas, the side of the road slopes down into a ravine. Gus Smithhisler, the Roadway Maintenance Program Manager for the Division of Engineering with ODNR, and the client representative, Chad Smith, indicated that the areas with steep slopes would require a large amount of fill and leveling. The occurrence and distribution of these slopes was identified and mapped (Figure 6). Steep slopes occur on the inside and outside of Main Loop Road.

FIGURE 5 ROADSIDE SLOPE ALONG MAIN LOOP ROAD AT HWSP

In addition to the slopes on the sides of the road, the roadway contains eight hills with gradients ranging from 6.2% to 11% (Figure 7 and 8). Each hill presents a challenge whether you are going up the hill or down the hill. Traveling up a steep hill can be physically challenging for recreational bicyclists or young children. And when traveling down the hills, one can reach speeds that are dangerous for an average bicyclist or young child. This is especially risky for bicyclists when traveling on the road with vehicles. For these reasons, the AASHTO Manual recommends avoiding hills of 5% gradient or greater whenever possible.

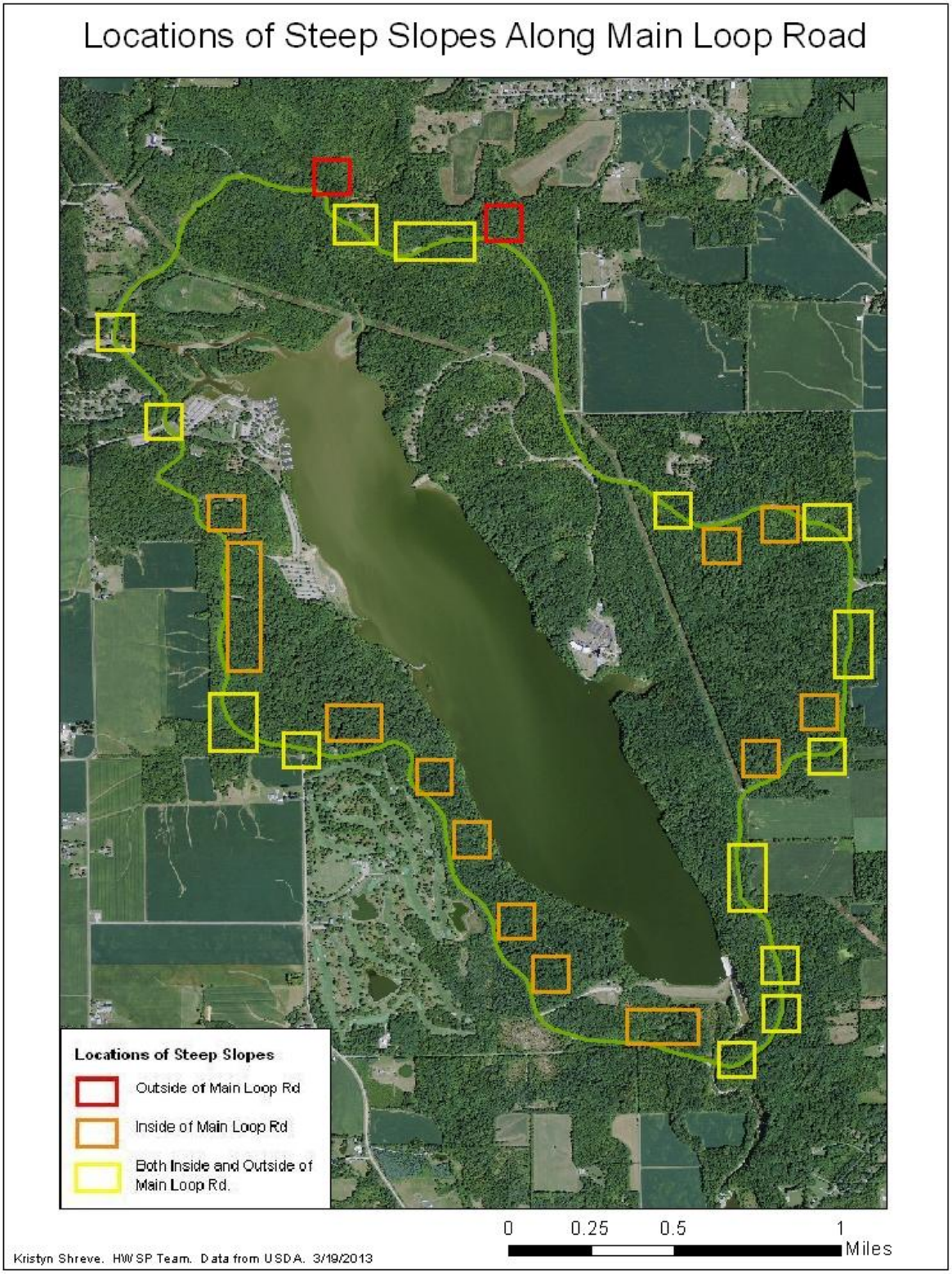


FIGURE 6 LOCATIONS OF STEEP SLOPES ALONG MAIN LOOP ROAD AT HWSP

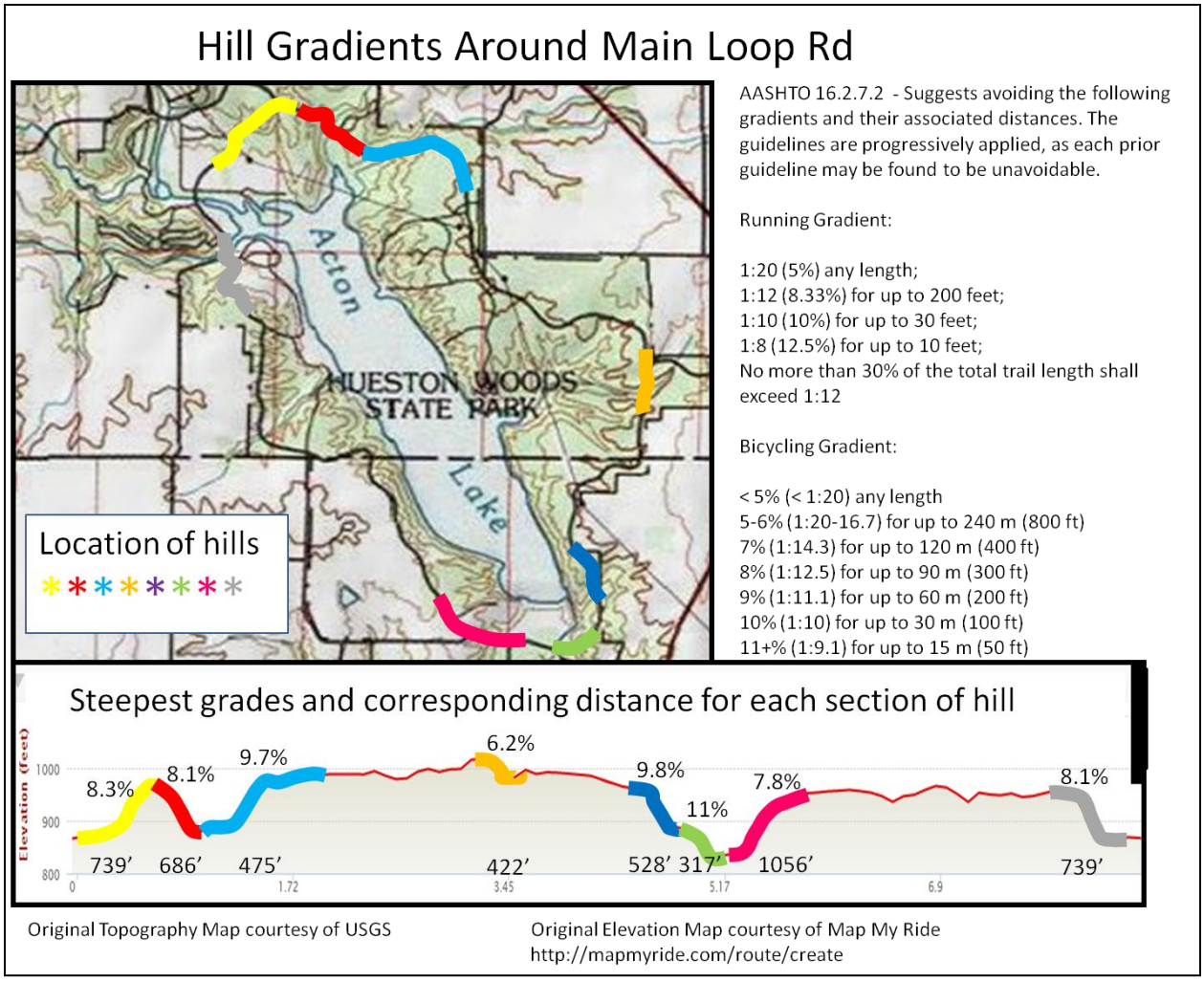


FIGURE 7 STEEP GRADIENTS AND THEIR CORRESPONDING DISTANCES ALONG MAIN LOOP ROAD

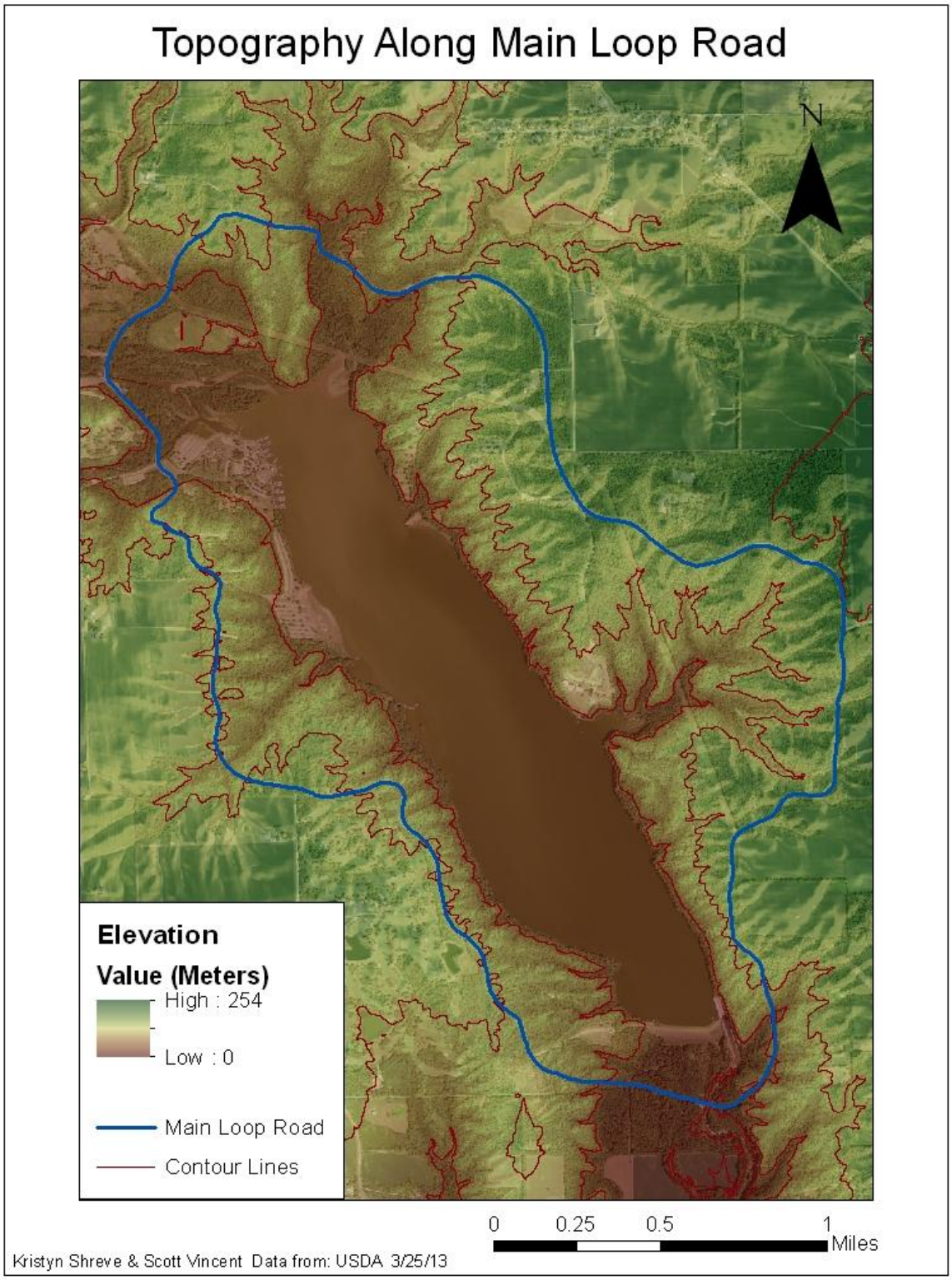


FIGURE 8 TOPOGRAPHY AT HWSP IN METERS

2.2 LEGAL TRAILBLOCKS

There are a number of environmental laws and regulations that apply to a project such as this. Ohio Department of Natural Resource's Division of Engineering would oversee a bikeway project at HWSP and coordinate with other agencies, such as the United States Army Corps of Engineers, the Ohio Department of Transportation, and the Ohio and United States Environmental Protection Agencies (Division of engineering 2007). For example, if any federal action is involved, the National Environmental Policy Act (NEPA) requires federal agencies to determine if any proposed action has the potential to affect the quality of the human environment. A federal action that would initiate NEPA might include financing, assisting, conducting, or approving the bikeway project (U.S. Environmental Protection Agency 2012).

If the bikeway project received federal funding or required a federal permit, then a NEPA analysis would be required. There are three levels of NEPA analysis: 1) categorical exclusions, 2) environmental assessments, and 3) environmental impact statements (U.S. Environmental Protection Agency 2012).

A federal action can be categorically excluded if it meets the criteria the federal agency has established as having no significant environmental impact. Many federal agencies have developed their own lists of categorical exclusions, which can be applied to projects of a similar nature, thus streamlining the process.

If a categorical exclusion does not apply, then an environmental assessment must be performed. A written environmental assessment must be prepared by the federal agency involved in the project to determine the context and intensity of the effects that may "significantly" affect the quality of the human environment (U.S. Executive Office of the President of the United States 2007). If the action does not significantly impact the environment then the federal agency can issue a finding of no significant impact (FONSI). The FONSI may require that the federal agency develop mitigation methods for potential environmental impacts (U.S. Executive Office of the President of the United States 2007).

If it is determined that the federal action will significantly impact the environment, then an environmental impact statement needs to be prepared (U.S. Environmental Protection Agency 2012). An environmental impact statement details what the impacts will be to the environment if the federal action takes place. This statement provides more in-depth actions and alternatives than that required by the Environmental Assessment. Outside parties such as the public and other agencies may also provide input into the environmental impact statement and comment on the draft of the statement. The outside input allows for the federal agency to take into consideration factors that may not have been considered (U.S. Environmental Protection Agency 2012).

In the case of a bikeway at HWSP, a categorical exclusion may apply under the Programmatic Categorical Exclusion Agreement between the Federal Highway Authority (FHWA), the Ohio Rail Development Commission and the Ohio Department of Transportation (Appendix E summarizes categorical exclusions). Under this agreement, the construction of bikeways can be considered a categorical exclusion exempt from further NEPA review, except in these cases:

1) Acquisition of new right-of-way,
2) Scenic River corridor impact,
3) Waterway Permits,
4) Impacts to wetlands,
5) Impacts to state or federally threatened or endangered species,
6) Impacts to historic properties or historic districts,
7) Impacts to park and recreation lands or impacts under the Land and Water Conservation Act,
8) Substantial traffic disruption,
9) Public controversy when all issues have been addressed (The Federal Highway Administration 2010).

The first two categories from the above list do not apply to this project because the proposed bikeway would follow the existing road, and there is no Scenic River corridor in HWSP. The remaining categories, however, may apply to the bikeway project. If so, then further NEPA analysis would be required. For instance, if the bikeway would require a waterway permit or impact wetlands, then the bikeway categorical exclusion may not apply. A National Pollutant Discharge Elimination System permit from the Ohio Environmental Protection Agency's Division of Surface Water would be required if any wastewater or stormwater from the bikeway construction would be discharged into "waters of the state", such as streams, rivers, or lakes. Likewise, if a wetland is impacted then certifications or permits may be required under Sections 401 or 404 of the Clean Water Act (Ohio Environmental Protection Agency 2013). The project team developed soil and drainage maps of HWSP to utilize if the Ohio Environmental Protection Agency assesses impacts to waterways and wetlands (Appendices F and G).

An initial investigation revealed that there may be no threatened or endangered species (category 5) that would be impacted by this project. However, if the project were to go forward, then one could request an assessment of the park from Ohio Natural Heritage Database. This Ohio Natural Heritage Database contains more than 19,000 records of locations of rare plants and animals, high quality plant communities, and other natural features found in Ohio (Ohio Department of Natural Resources 2013) (See Appendix H for the Natural Heritage Database Data Request Form, and see Appendices I and J for lists of threatened or endangered plant and animal species in Preble and Butler County). Likewise, it is unlikely that any historic sites will be impacted (category 6). While there are two historic sites on the property, a pioneer farm and Indian mound, neither are located near the study area (Ohio Historic Preservation Office 2013). However, these sites would still need to be listed in a NEPA report since they are located on the property that would undergo construction (U.S. Environmental Protection Agency 2012).

As for the other categories, it is difficult to analyze these at this point. However, if this project were to go forward, one would have to assess whether there would be substantial traffic disruption (category 7), appropriate use

of park lands (category 8), or substantial public controversy (category 9) to determine if the bikeway categorical exclusion would apply. While the Main Loop Road is used predominantly by park visitors, traffic disruption could occur during the busy season, or if it disrupted the flow of those who may use the park road to get to and from work or home. Public controversy could be an issue if the public would see this as an improper use of park land or funds. This could be addressed through public input meetings during initial planning stages (U.S. Executive Office of the President of the United States 2007). A survey about the public's perceptions and thoughts on a proposed bikeway at HWSP could be used in addition to public input meetings.

Another important consideration is the impact of a bikeway on the Hueston Woods Nature Preserve. Under Ohio law, nature preserves are sanctuaries for rare plants and animals (Preservation of Property 2007). According to HWSP's representative, Chad Smith, if a bikeway was constructed within twenty-five feet of the existing berm, then the HWSP nature preserve would not be disturbed.

2.3 SOCIAL TRAILBLOCKS

Finally, the public may also serve as a social trailblock for the potential bikeway at HWSP. Other bikeways have run into public opposition in the past. For example, in Missouri there was strong public opposition for a proposed bikeway, because it would intersect residents' yards and increase the likelihood that trespassers would access their property (Hackbarth 2011). However, the HWSP bikeway would not enter private property. Another project—a mountain bike trail in Mt. Hood National Forest, Portland, Oregon—received opposition from environmentalists. They argued that the soil in the area was not fit for construction, and the bike trail would lead to erosion affecting vegetation in the area (Anderson 2012). Additional research suggests that anthropogenic disturbances negatively affect growth of vegetation and avian communities (Beissinger and Osborne 1982). Consequences, such as these, could create public controversy. Seeking community input is an essential step for any major public project.

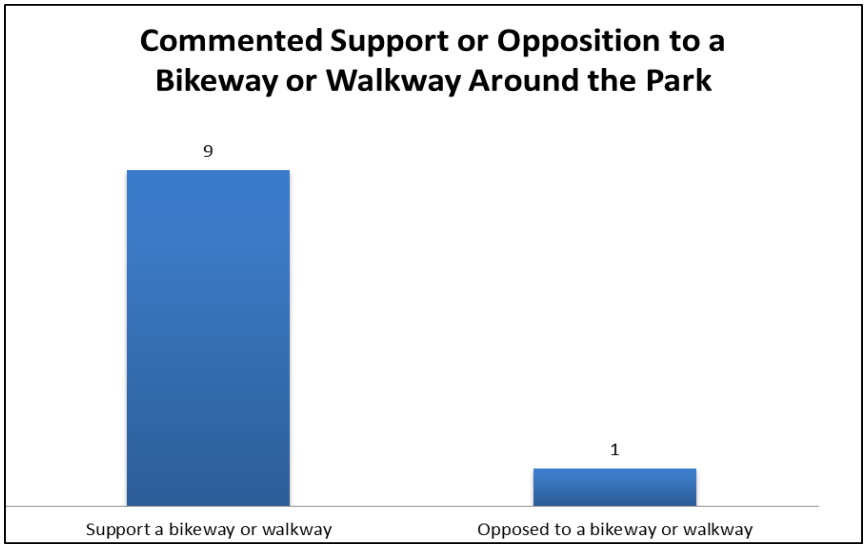


FIGURE 9 PREFERENCES FOUND FROM THE EXPLORATORY SURVEY

To gather public input from HWSP's visitors, the project team surveyed a subset of HWSP visitors. This survey only inquired about safety, to ensure the public would not be misled into thinking a bikeway was going to be implemented at the park. However, some individuals who took the survey were able to guess that a bikeway may be implemented. At the end of the survey, participants could

write comments/suggestions. Without even stating HWSP was considering a bikeway, 9 people openly stated their support for a bikeway in HWSP and 1 person openly stated their opposition (Figure 9). The individual who opposed a bikeway at HWSP stated that they believed park funds could be better allocated for other purposes.

The survey is categorized as an exploratory survey because it sought individuals' perceived notions or thoughts on a particular topic (Dedman et al 2011), in this case safety, and not on the public's opinion about a bikeway. The survey revealed that while 71% of respondents reported satisfaction with traveling around HWSP without a motor vehicle, 32% of respondents indicated that they had safety concerns when walking or biking along Main Loop road (Tables 2-5).

While this information provides valuable insight, it does not necessarily represent the opinions of the entire HWSP visitor populations. A more in-depth analysis could be done to encompass all user groups utilizing different modes of distribution, including placing web-based surveys on different online sources and creating paper based surveys for use at the park. Surveys should also be distributed during different seasons to incorporate input of guests who visit the park during different times of the year. This analysis would provide a better understanding of how the different user groups of HWSP perceive safety on the Main Loop Road (See Appendices K-O for more information about this survey).

TABLE 2 SURVEY QUESTION 4

If you travel around the park without a motor vehicle, how satisfied are you with getting around the park?

#	Answer	Response	%	
1	Very Satisfied	11	17%	
2	Satisfied	19	29%	~71%
3	Somewhat Satisfied	16	25%	
4	Neutral	10	15%	
5	Somewhat Dissatisfied	8	12%	~14%
6	Dissatisfied	1	2%	
7	Very Dissatisfied	0	0%	
	Total	65	100%	

TABLE 3 SURVEY QUESTION 5

Have you biked or walked along the Main Loop Road?

#	Answer	Response	%
1	Frequently	15	20%
2	Occasionally	42	56%
3	Not At All	18	24%
	Total	75	100%

TABLE 4 SURVEY QUESTION 6

If you answered "Frequently" or "Occasionally" for question 5 have you had any safety concerns or incidents?

#	Answer	Response	%
1	Yes	16	29%
2	Maybe	11	20%
3	No	28	51%
	Total	55	100%

TABLE 5 SURVEY QUESTION 7

Do you agree with this statement: "I feel safe biking or walking along the shoulder of the Main Loop Road in the park?"

#	Answer	Response	%	
1	Strongly Agree	4	7%	~ 49%
2	Agree	24	42%	
3	Neither Agree nor Disagree	11	19%	
4	Disagree	13	23%	~ 32%
5	Strongly Disagree	5	9%	
6	I do not bike or walk around the Main Loop Road	0	0%	
	Total	57	100%	

3.0 BIKEWAY ALTERNATIVES

To provide HWSP with recommendations for a safe, cost efficient and environmentally responsible path along Main Loop Road, bikeway alternatives were developed using the AASHTO Manual (See Appendix P for a table of these alternatives). The analysis considers factors such as road condition and type (urban, residential, rural, highway), the amount of traffic, expected or normal users, presence of steep grades that would impact cyclists, intersections that could impact safety, trailblocks, and estimated costs. The team also utilized a bicycle Level-of-Service (LOS) calculator from the Highway Capacity Manual, which assigns a score to a roadway based on these conditions, and essentially defines the usability for cyclists. The range of scores of the LOS is A through F, with a score of A considered an extremely high compatibility level for a cyclist on that particular road and a score of F is considered extremely low (Table 6) (See Appendix Q for summaries of LOS calculations). In addition, to prevent conflict with Ohio law, only alternatives that could be implemented without entering the state nature preserve were considered.

TABLE 6 LEVEL OF SERVICE SCORES

Level-of-Service	Compatibility
A	Extremely High
B	Very High
C	Moderately High
D	Moderately Low
E	Very Low
F	Extremely Low

The current conditions at HWSP are similar to a rural road, with a low speed limit. There is one lane of travel going each direction, and a speed limit of 25mph. There are over 30 intersections, though roughly half of these provide access to service roads with very little traffic. Main Loop Road has one stop sign and no traffic signals. According to a study conducted by ODOT, roughly 1,000 vehicles a day travel along Main Loop Road during the summer (see Appendix R).

The project team performed random samples of the road width and shoulder width. The average road width per lane is 12 feet and the average shoulder width is just over 6 inches (see Appendix S for sampled measurements and location of samples).

As previously stated, several points along Main Loop Road are steep, and could be challenging for an average bicyclist. Main Loop Road has at least 8 hills with grades greater than 5%. Six of those hills have grades greater than 8% (see Appendix T). These hills may make it difficult and unsafe for some bicyclists who are less confident in their cycling ability or who may have lower levels of fitness. These grades may prevent bicyclists from reaching popular destinations in the park, such as the marina, nature center, lodge, and campground, which are separated by at least one steep hill.

TYPES OF BIKEWAYS

The AASHTO Manual identifies eight major classifications of bikeways. Appendix U provides a summary table of these bikeways.

1. **SHARED LANES:** Bicyclists operate on the roadway in the vehicle lane with the vehicles. Generally, this is a good option on rural roads and when the traffic volume is less than 1,000 vehicles per day.
2. **SHARED LANES WITH WIDE OUTSIDE LANES:** Bicyclists continue to operate on the roadway, but the outer lane is widened to allow cars to pass the bicyclist without encroaching on the other vehicle lane. Intended for major roads that generally have more than 3,000 vehicles per day.
3. **MARKED SHARED LANES:** Bicyclists operate on the roadway with vehicles, with the addition of a shared-lane marking on the road. A good alternative when space-constraints prevent the implementation of more elaborate bikeways. Generally used when the vehicle speed is less than 35 mph.
4. **PAVED SHOULDERS:** Approximately 4 feet of a paved shoulder are available on both sides of the road to accommodate bicyclists. The shoulder can be used for bicyclists, pedestrians and as vehicle parking. Intended for rural roadways or inter-city highways.
5. **BIKE LANES:** Approximately 4-5 feet of dedicated bicycle travel lane are designed specifically for bicyclists. A bike lane is considered a travel lane therefore it is not to be used for vehicular parking. Bike lanes are intended for major roads with a speed limit exceeding 25 mph.
6. **BICYCLE BOULEVARDS:** Streets that have been modified to act as through streets for bicyclists, which discourages automobile through-traffic. Intended for local roads with low traffic volumes, such as residential roadways, with less than 3,000 vehicles per day and where the speed limit is less than 25 mph.
7. **SHARED USE PATH WITH INDEPENDENT RIGHT-OF-WAY:** Bikeway that is totally separated from the road, which then has its own right-of-way. An example of this bikeway can be seen in bike paths that have been created in greenways, abandoned rail lines or freeways.
8. **SIDEPATH (SHARED USE PATH ADJACENT TO A ROADWAY):** Bikeway that is separated from the road by 5 feet or a physical barrier. A good option when the vehicular road is high-speed or has high vehicle traffic.

RULED OUT ALTERNATIVES

Based on the team's analysis of the roadway, three of these bikeway options do not meet the needs of HWSP. The ruled out alternatives are (2) shared lanes with wide outside lanes, (6) bicycle boulevards and (7) shared use paths with independent right-of-way. Listed below are explanations for eliminating these three alternatives:

- **SHARED LANES WITH WIDE OUTSIDE LANES:** The current width of Main Loop Road does not permit this alternative to be implemented. Additionally, this bikeway is generally best utilized when the traffic is greater than 3,000 vehicles per day. HWSP's traffic count is well under this 3,000 vehicle per day recommendation (see traffic count Appendix R). If the park expanded the road, the better alternatives would be paved shoulders or bike lanes, which are discussed below.
- **BICYCLE BOULEVARDS:** This type of bikeway is generally used in an urban environment, and is intended to deter vehicles from using the road. Because HWSP is located in a rural area and Main Loop Road is the only road around the park, deterring vehicles from the road is not an option.

- **SHARED USE PATH WITH INDEPENDENT RIGHT-OF-WAYS:** This type of bikeway is not intended for use along a roadway. It is intended to be separated from the road and within its own right-of-way. The goal of the present project is to provide recommendations for a bikeway adjacent to Main Loop Road; therefore, this alternative would not meet the specifications desired. However, the project team explored this alternative to see if grades greater than 5% on Main Loop Road could be avoided. Three potential areas were identified but were determined to be unacceptable. Either the terrain around these areas is extremely steep, or they did not provide a safer alternative. Despite not being potential options for this project, two of the three sites may be good alternatives for other park projects. See Appendix V for more information about these sites and their potential application.

3.1 BIKEWAY ALTERNATIVE 1: MAINTAIN SHARED LANES

TABLE 7 SHARED LANES

Shared lanes (current designation)	• Bicyclists are expected to ride with traffic in the vehicle lane. Shoulder width varies, but is not wide enough to accommodate bicyclists.	

The first alternative is to maintain shared lanes. A shared lane is one where vehicles and bicyclists share the same roadway. This can be used to describe the current situation at HWSP (Association of State Highway 2012). The AASHTO Manual depicts shared lanes as an appropriate bikeway for HWSP, because Main Loop Road is a rural road with little vehicular traffic—only 1,000 vehicles per day (Association of State Highway 2012).

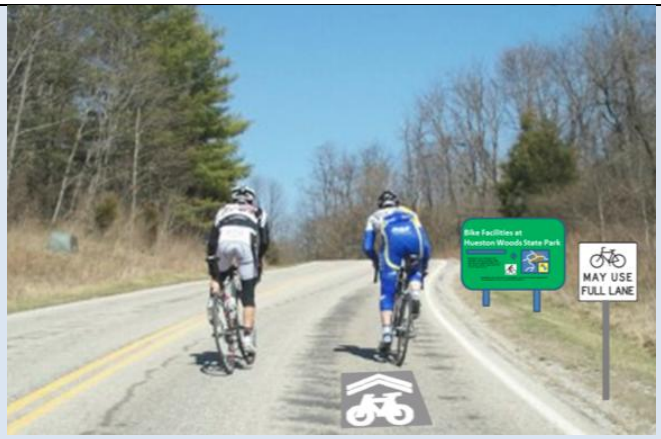
The bicycle LOS score for this alternative is C. This score means that the road has a moderately high compatibility for bicyclists on the road.

The primary benefit of maintaining shared lanes on Main Loop Road is a financial one, with no additional costs associated with making changes to the road. Because there is no construction to the roadway, the trailblocks (i.e., culverts, bridges, junction boxes) mentioned earlier in the report would not pose a problem.

There are risks associated with keeping the current shared lane pattern, including the perceived lack of safety while bicycling on Main Loop Road. Since there are no specific measures taken to make riding on the road safer, there is the potential for an accident by having bicyclists and vehicles sharing a lane.

3.2 BIKEWAY ALTERNATIVE 2: ADD SHARED-LANE MARKINGS, SIGNAGE AND A BICYCLE EDUCATION PROGRAM (MARKED SHARED LANES)

TABLE 8 MARKED SHARED LANE WITH ADDITIONAL SIGNS AND EDUCATION

Marked shared lane with additional signs & education	• Addition of shared lane markings on vehicle lane • Addition of bicycle related signs • Implementation of bicycle education program	

Another bikeway alternative for HWSP is to maintain the current shared-lane conditions, but to add three additional safety measures: 1) shared-lane markings to the pavement, 2) road signs indicating that bicyclists may use the road, and 3) a bicycle education program.

The shared-lane marking is a painted symbol on the pavement that provides a higher level of guidance to both bicyclist and motorist (Figure 10) (Association of State Highway 2012). This marking should be placed at least 4 feet from the edge of the side of the vehicle lane (Ohio Department of Transportation 2012). The marking raises awareness and safety by informing drivers that bicyclists are likely to occupy the same lane. These markings also inform bicyclists where they should ride on the road (Association of State Highway 2012).

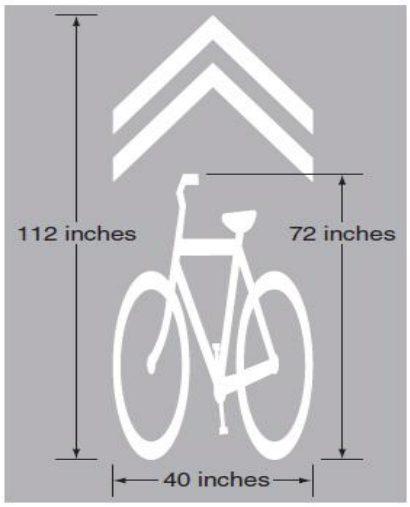


FIGURE 10 SHARED LANE MARKING (Toole 2012)

The second component of this alternative is the addition of bicycle related signage (Figures 11 and 12). These signs would be intended to alert travelers that bicyclists are expected to ride in the vehicle lane. The addition of bicycle signs may also increase a visitor's experience by directing them to different amenities and destinations within HWSP. These signs could point bicyclists towards Oxford, HWSP's mountain bike trails and park facilities, or other bicycle routes (Figure 13). More information about Ohio Manual of Uniform Traffic Control Devices and the requirements for the signs can be found in Appendix W.

Implementation of a bicycle education program is the last component of this alternative. To increase educational awareness, bicycle safety information can be displayed on the park's kiosks. Pamphlets could be produced explaining the park's bikeway, expectations for those who are bicycling or driving in the park, and general bicycling safety practices like wearing helmets and communicating to drivers with standard hand gestures. Bicycle training sessions may also be another way to educate and establish a higher level of safety within the park. For instance, a program in Pima County, Arizona, promotes bicyclist safety by offering free bicycle classes (Pima County DOT 2013). ODOT's Cycling Smarter Guide is a comprehensive resource that may assist in developing safety material for HWSP. This guide discusses bicycle laws in Ohio and general safety practices (Ohio Department of Transportation 2 2013).

FIGURE 11 BICYCLES "MAY USE FULL LANE" SIGN
(Toole 2012)

FIGURE 12 "WRONG WAY, RIDE WITH TRAFFIC" SIGN
(Toole 2012)

Some benefits of this alternative include low cost and short time to completion. The cost for this alternative would be relatively low compared to other options, because HWSP can rely on internal departments to make and install the signs. This alternative can be completed almost immediately since it would require no construction to the roadway. Additionally, the physical trailblocks (i.e., culverts, bridges, junction boxes) mentioned earlier in the report would not present a problem. Similar to the first alternative, the bicycle LOS score for this alternative is also C—a moderately high compatibility for bicyclists on the road. Implementation of this alternative will pose some challenges. Though the park is able to install the required markings and signs, there will be some additional costs of making and maintaining the markings and signs. HWSP will also need the personnel to design and carry out the education program, which may create additional responsibilities for staff.

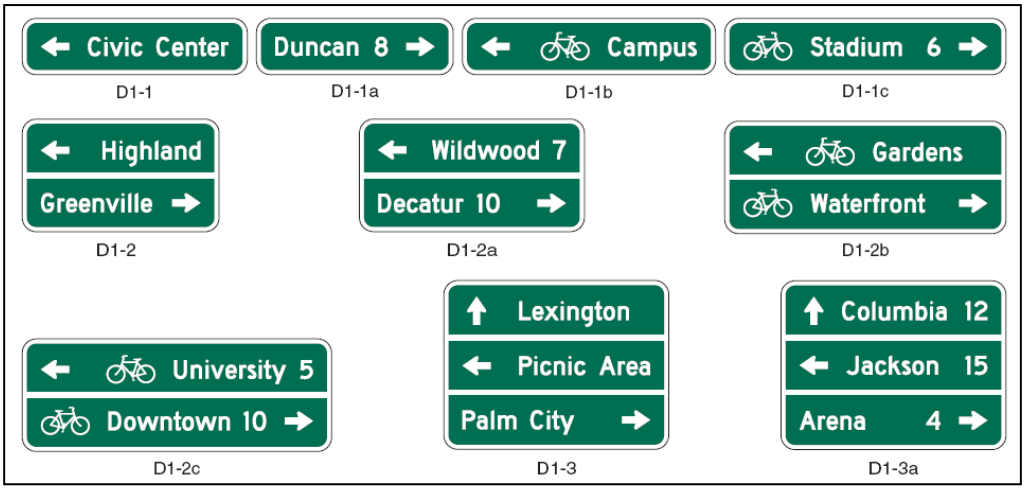
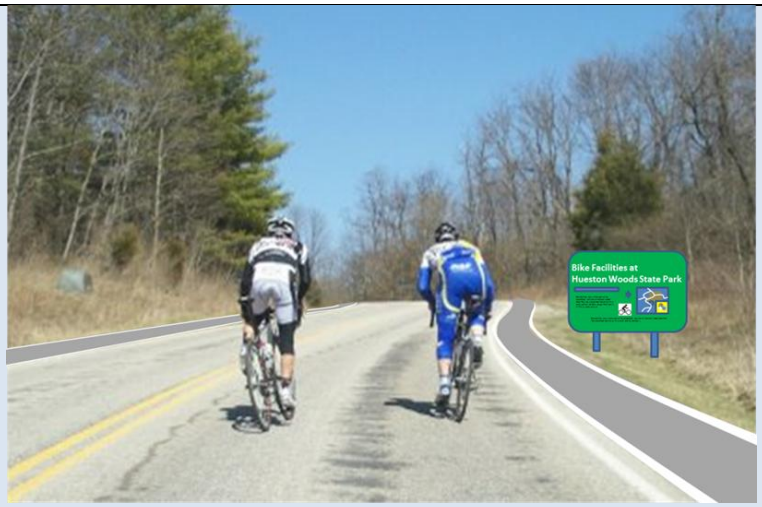


FIGURE 13 EXAMPLE OF SIGNS TO PROMOTE TOURISM
(Toole 2012)

3.3 BIKEWAY ALTERNATIVE 3: PAVED SHOULDER

TABLE 9 PAVED SHOULDERS

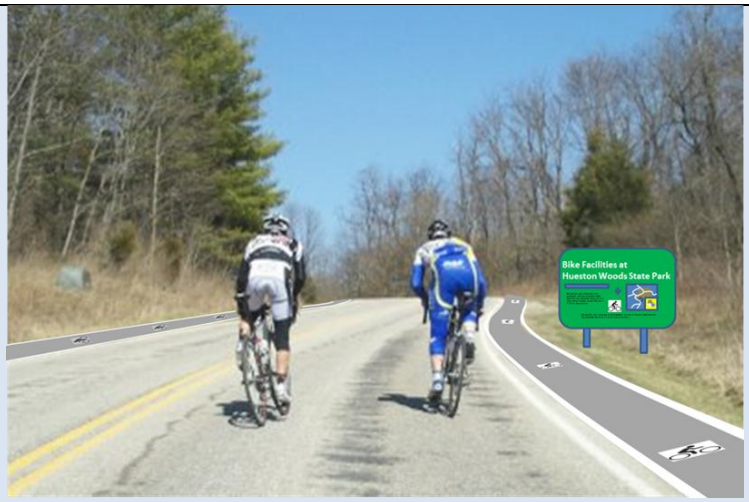
Paved shoulders	• Addition of bicycle related signs • Bicycle safety education provided by HWSP • Widening the road on both sides to have bicyclists ride outside the vehicle lane	

A paved shoulder is an extension of the roadway on either side. The AASHTO Manual recommends a minimum width of 4 feet, which allows cyclists a paved area outside of vehicle traffic. In addition to providing a space for bicyclists, paved shoulders also have the following benefits: 1) provide space for pedestrians, 2) provide a temporary location for disabled vehicles, and 3) reduce road edge deterioration (Association of State Highway 2012). The bicycle LOS score for this alternative is a B, which gives it a very high compatibility score.

Installing a paved shoulder at HWSP would require widening Main Loop Road by at least 4 feet on each side. This width, however, can be adjusted as necessary to work around the trailblocks. For instance, if the cost to move utility poles or junction boxes would be cost prohibitive, then the paved shoulder could only be added in sections without these trailblocks. Likewise, a 4-foot wide paved shoulder may not be possible near the culverts or across the bridge. According to the AASHTO Manual, it is acceptable to adjust for these trailblocks. A 4-foot wide paved shoulder on both sides of Main Loop Road would cost approximately $1.75 million for materials only. This estimate is based on consultations with ODOT's Office of Estimating (see Appendix X).

3.4 BIKEWAY ALTERNATIVE 4: BIKE LANE

TABLE 10 BIKE LANE

Bike Lane	• Addition of bicycle related signs • Bicycle safety education provided by HWSP • Widening the road to have bicyclists ride outside the vehicle lane • Addition of bike lane symbol (Figure 14)	

Similar to a paved shoulder, a bike lane is an extension of the roadway on either side of the road (Figure 15) (Association of State Highway 2012). The primary distinction between paved shoulders and bike lanes is that bike lanes are considered travel lanes, while paved shoulders are not. This distinction is important to recognize as bike lanes are designed exclusively for bicyclists (Association of State Highway 2012). These lanes are recommended to be on both sides of the road, allowing bicyclists to ride in the same direction as traffic. A 4-foot wide bike lane would be suitable for HWSP, based on the low speed limit and low traffic numbers (Association of State Highway 2012).

A bike lane is a designated travel lane, and therefore it is not as flexible as the paved shoulder. Trailblocks would require the lane to merge with vehicle traffic, creating an undesirable bottleneck (Association of State Highway 2012). Conflicts between pedestrians and bicyclists are also a real possibility. Pedestrians may not understand that the bike lane is specifically for cyclists, and may still use it to travel along Main Loop Road. Like the paved shoulder, the bicycle LOS score for this alternative is a B, which is again a very high compatibility. However, this score does not take into account the limitations explained above.

FIGURE 14 "BIKE LANE" SIGN
(Toole 2012)

The cost of adding a bike lane to each side of the Main Loop Road is approximately $1.75 million for materials only. The park would cover any additional striping. This estimate is based on consultations with ODOT's Office of Estimating.

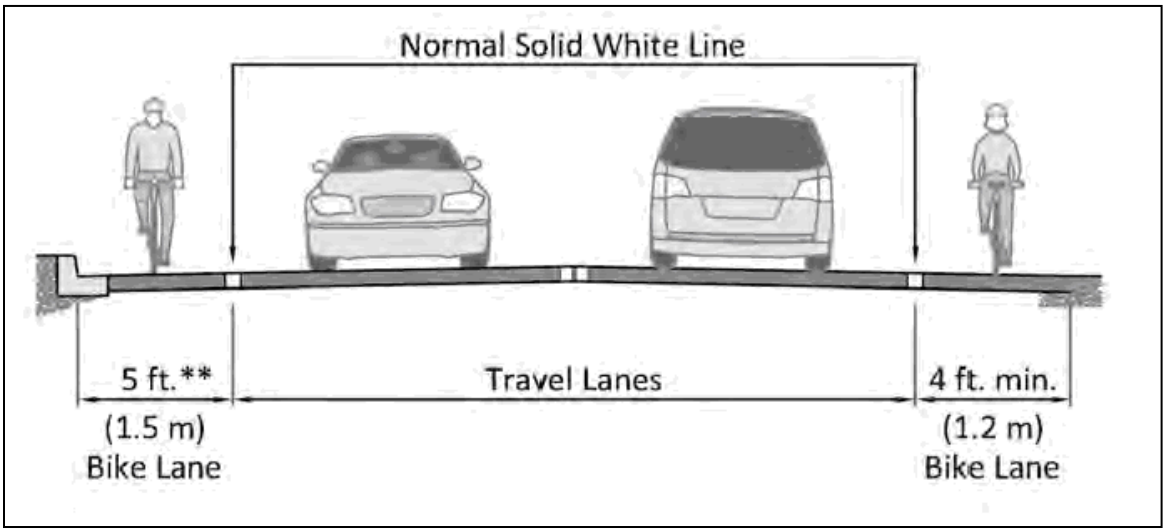
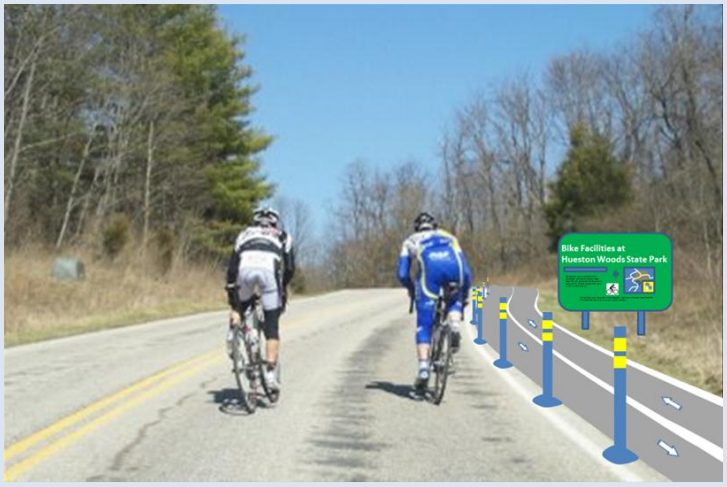


FIGURE 15 TYPICAL BIKE LANE CROSS SECTION
(Toole 2012)

3.5 BIKEWAY ALTERNATIVE 5: SIDEPATH

TABLE 11 SIDEPATH

Shared use path: adjacent to the road (sidepath)	• Addition of bicycle related signs • Bicycle safety education provided by HWSP • Widening the road to have bicyclists ride outside the vehicle lane • Must meet ADA guidelines because it is a multi-use path • Either requires a separation of 5 feet from the road or a barrier between the road and the path.	

The last alternative is a more complex design than the alternatives outlined above. A sidepath is a multi-use path that runs adjacent to a roadway. Sometimes referred to as a trail, sidepaths are paved, designed for two-way traffic, and are accessible to multiple users, including cyclists, walkers, runners, and inline skaters. Sidepaths can be

thought of as an off-road transportation network that complements the existing roadway (Association of State Highway 2012).

Sidepaths are designed for multiple users, and therefore need to be designed according to Americans with Disabilities Act (ADA) regulations (Association of State Highway 2012). These regulations can be met by following the guidelines from the AASHTO Manual, as the ADA guidelines are less stringent than the regulations for bicycle facilities (see Appendix Y). The paths are designed with an adult bicyclist in mind, as this tends to be the most frequent user. A minimum width is 10 feet, but they typically range from 10 to 14 feet. Striping is useful to indicate lanes and flow of traffic (Association of State Highway 2012).

A sidepath would involve widening Main Loop Road a minimum of 10 feet on one side. It would require separation from the roadway, either a barrier or a separation of at least 5 feet. Because of the space constraints at HWSP, a separation is not practical. A barrier, such as flexible spring back bollards would need to be installed to separate the sidepath from vehicular traffic (Figure 16).

FIGURE 16 FLEXIBLE SPRING BACK BOLLARDS
(The Traffic Safety Store 2013)

There are several concerns with this alternative. Initially, sidepaths create additional conflict at intersections, as motorists may not be expecting two-way cycling traffic on one side of the road. Motorists often block sidepaths as they wait to enter the roadway, and requiring cyclists to yield or stop is impractical. Two-way cycling/pedestrian traffic on one side of the road may require crossing points of Main Loop Road, depending on where the path users enter the park. Additionally, fixed obstacles may require the path to be narrowed, and in the case of HWSP, would require the path to be eliminated at several points to cross bridges and culverts where there is no opportunity to widen the roadway. The need to pave an additional ten feet at a minimum may also be impractical (Association of State Highway 2012). The bicycle LOS score for this alternative would be an A, which is a compatibility rating of extremely high. However, like the bike lane alternative, this score does not take into account the limitations explained above.

The cost of adding a sidepath would be approximately $3.75 to $4.5 million for materials only. These materials include the necessary sidepath barrier (Appendix X). The park would cover any lane striping. This estimate is based on consultations with ODOT's Office of Estimating. However, a major hindrance to this alternative is the steep slopes next to the road identified in Figure 6. The estimation of cost for filling in these areas

has been determined to be outside the scope of this project, and more than likely impractical for the park. So the actual cost of a sidepath would potentially be much greater than the above estimate.

BIKEWAY ALTERNATIVES COMPARISON

To assist in comparing the five alternatives, a table was constructed to display key elements of each alternative:

TABLE 12 BIKEWAY ALTERNATIVES COMPARISON TABLE

Alternatives	Cost of Materials (A)	Level-of-Service Score (B)	Ease of Implementation (C)	Avoids Interference from Unmovable Trailblocks (D)	Additional Maintenance Requirements? (E)	Explanation of Category Evaluation
Alternative 1: Maintain Shared Lanes	$0	C	No implementation necessary	Yes	None	**(A) Cost of materials was determined as a proxy for estimate of total cost based on estimates in Appendix X**
Alternative 2: Add Shared-Lane Markings, Signage and a Bicycle Education Program	$0	C	Almost immediate implementation, not resource intensive	Yes	Minor	**(B) Level-of-Service Score is based on Appendix Q**
Alternative 3: Paved Shoulder	$1.75 million	B	Requires funding, permitting, and construction	Yes/No - shoulder does not have right-of-way expectations	Minor, but may extend life of road	**(C) Ease of implementation considers time, resources, funding, permitting, and construction requirements**
Alternative 4: Bike Lane	$1.75 million	B	Requires funding, permitting, and construction	No	More significant, but may extend life of road	**(D) Avoids Interference from Unmovable Trail Blocks considers interruption of flow and right-of-way or pedestrians and cyclists**
Alternative 5: Side Path	$3.75-$4.5 million	A	Requires funding, permitting, and construction	No	More significant, but may extend life of road	**(E) Additional Maintenance Requirement considers routine up keep of facilities: clear paths where expected, visible signage and road markings**

4.0 RECOMMENDATIONS

4.1 MAIN RECOMMENDATION: MARKED SHARED LANES

Given the goal of providing recommendations for a safe, cost efficient and environmentally responsible path along Main Loop Road, the HWSP project team recommends maintaining current shared lanes and adding shared-lane markings, signage and a bicycle education program (Figure 17).

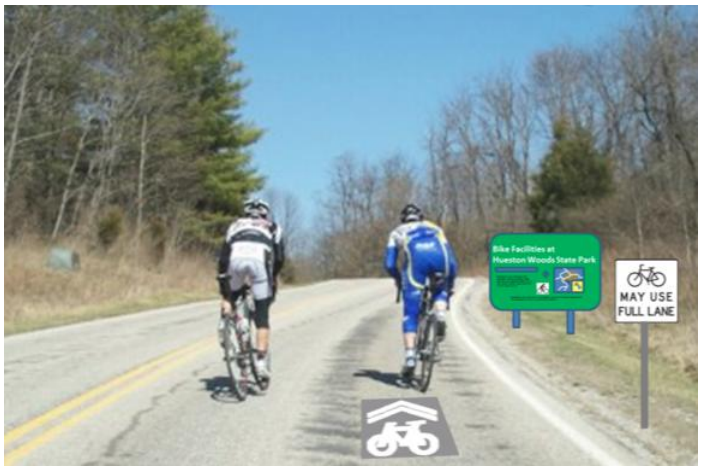


FIGURE 17 ALTERNATIVE 2 MARKED SHARED LANES

The current conditions along Main Loop Road are appropriate for marked shared lanes. The LOS calculator score of C illustrates that Main Loop Road is moderately compatible for marked shared lanes; meaning the speed limit, road condition, and traffic count are all suitable for this type of bikeway. The addition of markings, signage, and an education program will then act to improve safety through heightened awareness.

In addition, since no alternative can avoid bridges and culverts, it may be beneficial to maintain a shared roadway because it prevents bottlenecks and confusion where bicyclists and pedestrians would otherwise have to merge with vehicle traffic. Using this alternative will also prevent the confusion that occurs at intersections when bikeways cross prior to the main roadway. Because of right-of-way perceptions and additional lines of traffic away from the roadway, these intersections require higher levels of awareness to maintain safe conditions.

Marked shared lanes also have the additional benefit of being very cost efficient, environmentally friendly, and easy to implement. Because no additional pavement is required; costs and environmental impact are kept to a minimum, which is likely to reduce the level of permitting required as well as the need for additional funding. Because of these advantages, the marked shared lanes alternative has the potential to be implemented in the immediate future with minimal added resources.

4.2 ADDITIONAL RECOMMENDATIONS

Paved Shoulder with Main Loop Road Reconstruction

If a Main Loop Road reconstruction project is planned, the project team recommends incorporating paved shoulders into the rebuilt roadway (Figure 18). The paved shoulder alternative would increase safety by adding distance between bicyclists/pedestrians and vehicle traffic. In addition, compared to other alternatives requiring additional pavement, paved shoulders allow more flexibility to avoid physical trailblocks. Unlike a bike lane, a paved shoulder does not carry with it right-of-way expectations, nor does it use designated roadway crossings required for bike lanes and sidepaths. While adding paved shoulders could be cost prohibitive, incorporating it with a roadway reconstruction project could make the cost more manageable.

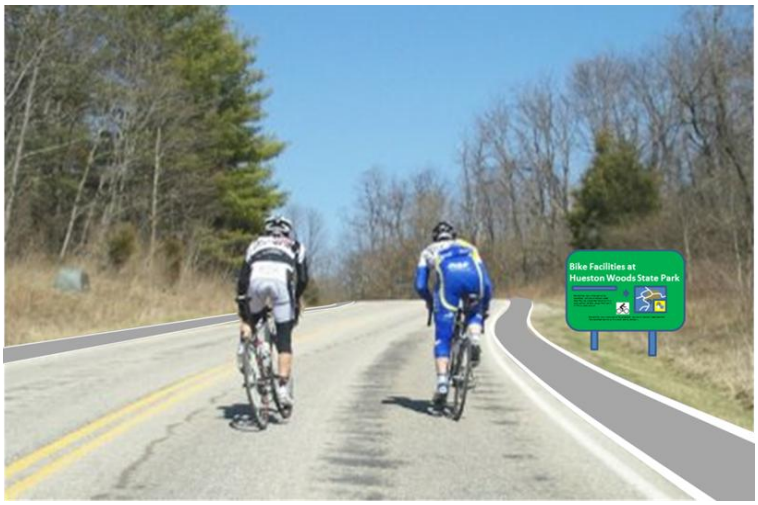


FIGURE 18 ALTERNATIVE 3 PAVED SHOULDER

Shared Use Paths with Independent Right-of-Ways

As mentioned previously (Section 3.0), several shared use paths with independent right-of-ways were investigated and eliminated as potential alternatives. Two small looping trails around the marina and hedge row were explored while attempting to find a path around steep hills along Main Loop Road. Though no effective roundabouts were found, the areas around the marina and hedge row are potentially suitable for additional bicycle and pedestrian travel. These trails have been mapped, and their benefits and drawbacks are discussed in Appendix V. These trails may warrant further investigation as HWSP looks for more ways to provide further recreational opportunities.

Potential Connections to Other Bikeways

It is important to note that HWSP does not exist in a vacuum. There are several other bikeways in Preble and Butler Counties, and there may someday be the potential for a connected trail system that could include HWSP. One of these bikeways, the Oxford Perimeter Path, when completed, will only be 3 miles to the south of HWSP. While this project is still in development, the opportunity for connection may present itself in the future and should be taken into account prior to the development of a HWSP bikeway (Appendix Z).

Additional Public Input

HWSP's decisions on bicycle and pedestrian travel would be better informed given a larger and more detailed account of public use and opinions. The project team recommends gathering additional information through further public surveying and public forum meetings prior to any new recreational developments. This is especially true as additional surveys may ask more in-depth questions than the exploratory survey, as HWSP will be less restricted by IRB considerations and creating false expectations for a bikeway.

In summary, the HWSP project team recommends the marked shared lanes alternative as it best provides a safe, cost efficient, and environmentally responsible bikeway around Main Loop Road. This alternative improves safety through awareness and education, minimizes expenses and environmental impact, and can be implemented in the near future. If a Main Loop Road reconstruction project is planned, the project team recommends consideration of the paved shoulder alternative. This alternative provides space between bicyclists/pedestrians and vehicle traffic, while safely managing the effects of bridges, culverts, and intersections. Furthermore, the project team recommends considering potential shared use paths with independent right-of-ways, considering potential connections to trail systems outside of the park, and gathering further public input to better inform the park of its users' needs.

HWSP has long provided an opportunity for its users to commune with nature and each other in a beautiful and welcoming environment that encourages recreation and education. This project has been just another outgrowth of the park's many efforts to best serve their community. The HWSP project team has felt privileged to have had the opportunity to contribute to those efforts.

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6.0 APPENDICES

APPENDIX A. GIS INFORMATION

Geographic Information Systems (GIS) is software used to manage and analyze geographic data. Multiple maps were created using GIS to supplement the Hueston Woods Bikeway Feasibility Study. This covers the methodology used in the study.

A high quality basemap of HWSP was obtained from the U.S. Department of Agriculture (USDA) website. After cutting the basemap down to a manageable size it was used to create many maps in the GIS program ArcGIS version 10.1.

GPS data points were collected using Magellan and Garmin Global Positioning System (GPS) units using either the "track" or "waypoint" function depending on the type of data being collected. The points were loaded onto the computer using the Minnesota Department of Natural Resources (DNR) Garmin program. The points were saved as unprojected shapefiles and loaded into ArcGIS. Using "Define Projection" in ArcGIS, the shapefiles were projected into a North American Datum (NAD) 1983 projection. After this the shapefiles were ready to use. Files created with this method include shapefiles of Main Loop Road, physical obstacles including utility poles, junction boxes, bridges, culverts, and wire beams, and points of slope and shoulder width measurements along the road.

The USDA Web Soil Survey website was utilized to create shapefiles as well. The HWSP boundary and nature preserve boundary shapefiles were created using Web Soil Survey. This was done by defining an Area of Interest (AOI). An AOI is defined using the rectangle or polygon tool and manually tracing the area that you want to create a shapefile for. You can then export the AOI as a shapefile and load it into ArcGIS. The park boundary and nature preserve boundary shapefiles were created using this method. After defining the AOI, a soil map was created by clicking the "Soil Map" tab and exporting the map as a pdf. A soil drainage map was also created by clicking the "Soil Properties and Qualities" tab and then clicking "Soil Qualities and Features" -> "Drainage Class".

In order to make the topography map we downloaded a raster file from the National Map site. We overlaid this file on top of our basemap and used the "Hillshade" function in ArcToolBox (ArcToolBox -> Spatial Analyst -> Surface -> Hillshade).

The triangulated irregular network (TIN) is a visual 3-D representation of the surface. A TIN map was made to show the elevation profile of Main Loop Road. This was done by transforming the raster to a TIN format and overlaying the shapefile for Main Loop Road.

Finally, a geodatabase was produced to combine all the data collected throughout the Hueston Woods Bikeway Feasibility Project. The geodatabase was necessary to compile the files into one spot where they can be used by the client for future use. All shapefiles created using a GPS or Web Soil Survey are included in the database as well as the "Hillshade" and TIN data sources.

APPENDIX B. BUDGET

Category	Unit	Cost Per Unit	Total Units	Total
Graduate Student	Hour	$12	1578	$18,936.00
Consultants (Graduate Student)	Hour	$12	26	$312.00
Copies (Black & White)	Page	$0.06	500	$30.00
Poster Printing	Each	Varied	9	$111.00
Mileage	Miles	$0.56	360	$199.80
Total Cost				**$19,588.80**

Hueston Woods State Park Bikeway Feasibility Study

Jason Bracken, Tom Buckley, Abigail Burns, Jeena Credico, Justin Hoffer, Kristyn Shreve
Institute for the Environment and Sustainability, Miami University

Introduction

Hueston Woods State Park is one of the top five most visited parks in Ohio. Its 3,000 acres are visited by about 2.5 million people each year [1]. Its natural areas support wildlife preservation and offer opportunities for a number of recreational activities. There are more than 46 miles of hiking, cycling and equestrian trails in the park [2]. However, there is no trail along the Main Loop Road, the primary route of travel throughout the park.

Problem Definition

The park has no means for bicyclists and pedestrians to travel safely along Main Loop Road, which connects all areas of the park.

Goal

Provide Hueston Woods State Park with a feasibility study that includes a recommendation for a safe, cost efficient and environmentally responsible multi-use path along Main Loop Road.

Objectives

- Identify challenges, such as environmental impacts and construction obstacles.
- Identify regulations associated with nature preserves and those created by the Ohio Department of Transportation.
- Develop a set of examples that demonstrate the best practices in multi-use path design and construction.
- Incorporate input from state employees and park visitors.
- Develop recommendations and alternatives.

Figure 1. Hueston Woods State Park is located in Preble and Butler counties in southwest Ohio. Main Loop Road around the park is highlighted in red.

Figure 2. Bicyclists riding on Main Loop Road in Hueston Woods State Park.

Figure 3. An urban bikeway. Photo by Living Streets Alliance.

Benefits

- Provide a safe means for pedestrians and cyclists to access different parts of the park from Main Loop Road.
- Promote tourism through the improved safety measures taken by the park.
- Improve health by encouraging non-vehicular transportation around the park.
- Provide integration to a potential bikeway coming from Oxford, Ohio.
- Educate park users regarding bicycle safety.

Study Design

- Research bikeway feasibility studies, bikeway regulations and biking safety measures.
- Research and survey the potential environmental impacts from bikeway installation.
- Explore obstacles to installing the bikeway.
- Map potential obstacles utilizing GPS and GIS technology.
- Consult experts to gain knowledge about ways to handle obstacles.
- Survey park visitors to gauge public opinion on current safety measures.
- Prepare a cost analysis and provide the client with potential sources of funding.
- Produce a final feasibility report including a bikeway recommendation and alternatives.

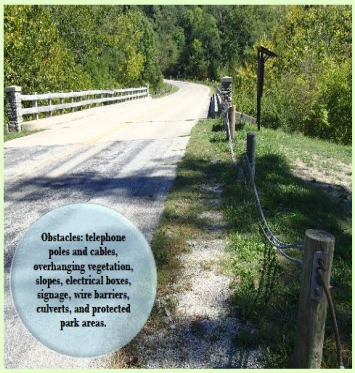


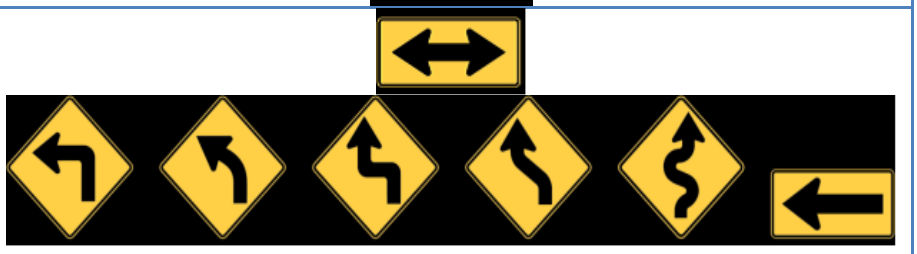
Figure 4. A bridge located on the Main Loop road is one of many obstacles to overcome when putting in a bikeway.

References

[1] Ohio Department of Natural Resources. (2010). "Ohio State Parks Annual Report." <http://www.dnr.state.oh.us/Portals/2/annualreports/2010annualreport.pdf> [Accessed Sept. 7, 2012].
[2] Ohio State Parks. (2012) "Hueston Woods State Park" <http://www.dnr.state.oh.us/tabid/745/default.aspx> [Accessed Sept. 7, 2012].

APPENDIX D. OPTIONAL SIGNS FOR ROAD HAZARDS

(Ohio Department of Transportation 2012)

Road Hazard	Signage
May use full lane: When there is no bike lane or shoulder present for bicyclists to use and when travel lanes are too narrow for bicyclists and motorists to operate side by side	
Selective exclusion signs: To specify which type of traffic users are excluded from the using the roadway or a facility	
No parking bike lane signs: Used to restrict parking, standing, or stopping in a bike lane	
Turn or curve warning signs: To alert bicyclists on a roadway, street, or shared use path of unexpected changes in a shared-use path direction. These signs should be installed at least 50 feet in advance of the beginning of the change of alignment	
Intersection warning signs: Used to alert bicyclists in advance of an intersection and the possibility of turning or entering traffic	

Bicycle surface condition warning sign: Used on a roadway or shared use path where conditions could cause a bicyclist to lose control of his/her bicycle	
Signs warning of other conditions: other signs that describe conditions that may be of concern to bicyclists	
Bicycle warning sign: To alert road users of unexpected entries into the roadway by bicyclists and other crossing activities that may cause problems. If sign is used at the location of the crossing then it shall be supplemented with a diagonal downward pointing arrow plaque to indicate the location of the crossing	
Path narrows sign: To warn bicyclists of conditions that are not apparent such as the path narrowing ahead	
Hill sign: To warn bicyclists of conditions that are not apparent such as a hill ahead	

APPENDIX E. CATEGORICAL EXCLUSIONS

Bikeway Projects involving any of the following impacts will not apply for a categorical exclusion under the programmatic categorical exclusion between ODOT and FWHA:

> "…acquisition of new right-of-way, Scenic River corridor impact, Waterway Permits, impacts to state or federally threatened or endangered species, impacts to wetlands, impacts to historic properties or historic districts, Section 4(1)/6(1) impacts, substantial traffic disruption, minor public controversy when all issues have been addressed." (The Federal Highway Administration 2010).

If none of these issues apply and the bikeway is expected to cause little or no impact to the environment, then the bikeway project would move on to the categorical exclusion level 1. However, if the project involved two or more of the following impacts, then this categorical level 1 would not apply:

> "Section 106 resource impacts resulting in 'No Adverse Effect', Programmatic or de minimis Section 4(f) impacts provided Programmatic Section 4(f) documentation has been approved by OES or de minimis Section 4(f) has been approved by FHWA. (A combined Section 106 and Section 4(f) impact on one resource qualifies a project for a CE Level 1), Impacts up to 3 acres of Category 1 and 2 wetlands only. (Enough information must be presented to issue a wetland finding) (A combined wetland impact and Individual 404 ACOE permit on one resource qualifies a project for a CE Level 1), Scenic River corridor impacts, Individual 404/401, Substantial traffic disruption, Minor public controversy when all issues have been addressed, Impacts to state or federally threatened or endangered species" (The Federal Highway Administration 2010).

If Categorical exclusion level 1 does not apply then the bikeway project can be evaluated under Categorical exclusion level 2. Categorical exclusion level 2 allows for:

> "Minor right-of-way (ROW) acquisition involving a maximum of two relocations (The context and intensity of the impact may require the CE to be elevated to the next higher level), Minor amounts of hazardous materials (involvement limited to petroleum related to underground storage tanks and/or releases), Impacts up to 3 acres of Category I and 2 wetlands and/or up to 0.5 acres of Category 3 wetlands (Enough information to issue a wetland finding must be included in the CE documentation), Section 106 impacts (no Archaeological Phase III recommendations) provided necessary documentation for consultation is included in the project files as required by 36 CFR Part 800, Programmatic or de minimis Section 4(f) impacts provided Programmatic Section 4(f) documentation has been approved by OES or de minimis Section 4(f) has been approved by FHWA, Minor public or agency controversy on environmental grounds" (The Federal Highway Administration 2010).

Categorical exclusion level 2 does not allow for:

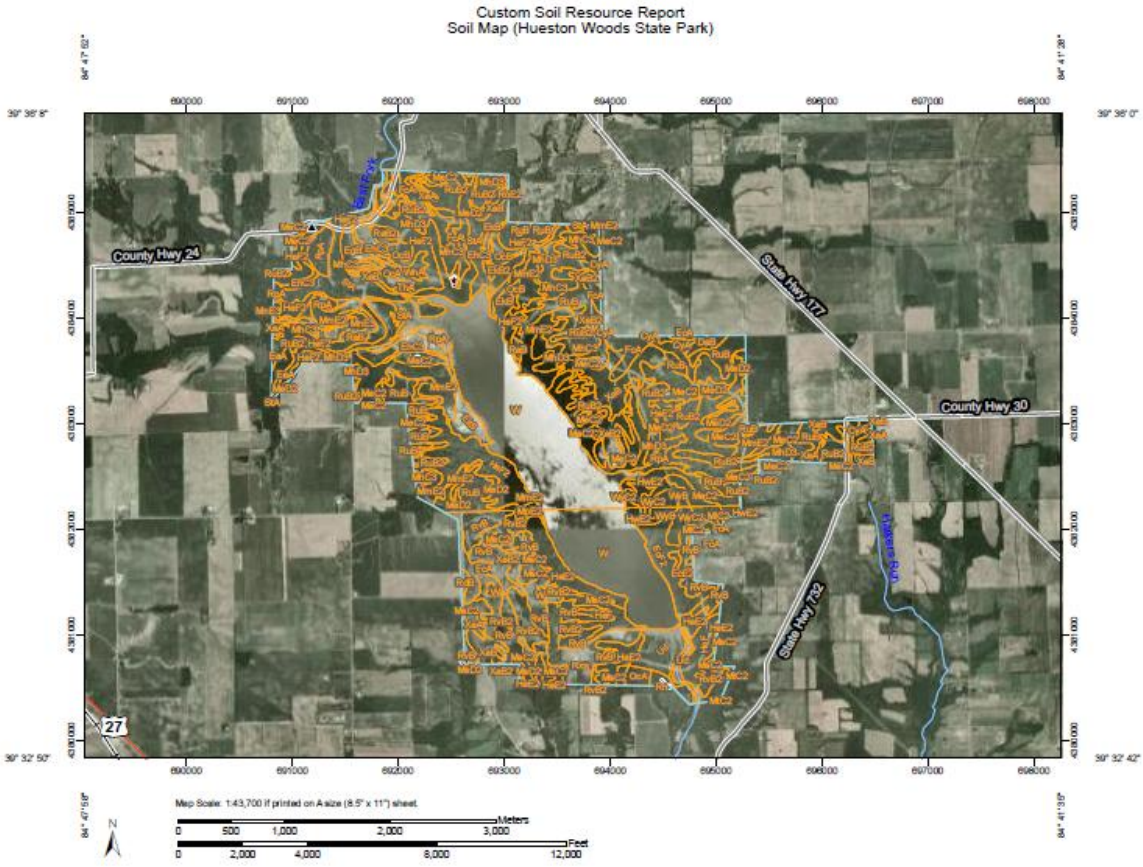
> "Addition of through travel lanes with more than I mile in length, Construction of an interchange to replace an existing at grade intersection, Coast Guard permit, Individual Section 4(f) impacts/use, Substantial flood plain impacts, Impacts to federally threatened or endangered species/"critical" habitat that results III a Biological Opinion, Any disproportionately high and adverse impacts relative to environmental justice" (The Federal Highway Administration 2010).

If any of these impacts apply then the bikeway project moves to the Categorical exclusion level 3. Categorical exclusion level 3 allows for:

> "Right-of-way (ROW) acquisition involving a maximum of eight relocations. (The context and intensity of the impact may require the CE to be elevated to the next higher level. Confirmation shall be made to determine that the acquisition will not result in significant impacts to the community or environment.), Section 106 impacts, provided necessary documentation of consultation is included in the project files as required by 36 CFR Part 800, Wetland impacts of 5 acres or less. (Enough information to issue a wetland finding must be included in the CE documentation.), Substantial public or agency controversy on environmental grounds (must be included in CE documentation that issues were addressed), Programmatic or de minimis Section 4(1) impacts provided Programmatic Section 4(1) documentation has been approved by OES or de minimis Section 4(1) has been approved by FHWA, Individual Section 4(1) impacts/use as long as a draft of the CE Level 3 is provided to FHWA for review along with the Individual 4(1) packet" (The Federal Highway Administration 2010).

Categorical exclusion level 3 does not allow for: "Substantial/significant flood plain impact, requiring an individual air quality analysis, any disproportionately high and adverse impact relative to environmental justice" (The Federal Highway Administration 2010). If the bikeway project does not apply for categorical exclusion level 3 and there are impacts associated with the project not discussed in the ODOT and FHWA categorical document, then it may move into categorical exclusion 4. However, these actions must be coordinated and approved by ODOT's Office of Environmental Services and FHWA.

(U.S. Department of Agriculture 2013)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:43,700 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:15,840.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Butler County, Ohio
Survey Area Data: Version 11, Oct 3, 2012

Soil Survey Area: Preble County, Ohio
Survey Area Data: Version 11, Jan 27, 2010

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: 6/23/2004

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Hueston Woods State Park)

Butler County, Ohio (OH017)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
EcE2	Eden silty clay loam, 15 to 25 percent slopes, moderately eroded	4.9	0.1%
EcF2	Eden silty clay loam, 25 to 50 percent slopes, moderately eroded	47.6	1.4%
FcA	Fincastle silt loam, 0 to 2 percent slopes	30.9	0.9%
HeE2	Hennepin-Miamian silt loams, 18 to 25 percent slopes, moderately eroded	92.0	2.7%
HeF	Hennepin-Miamian silt loams, 25 to 50 percent slopes	63.9	1.8%
HwE2	Hennepin-Wynn silt loams, 18 to 25 percent slopes, eroded	11.1	0.3%
MlC2	Miamian silt loam, 6 to 12 percent slopes, moderately eroded	10.7	0.3%
MpE2	Miamian-Hennepin silt loams, 18 to 25 percent slopes, eroded	4.0	0.1%
MsC2	Miamian-Russell silt loams, 6 to 12 percent slopes, moderately eroded	47.9	1.4%
MsD2	Miamian-Russell silt loams, 12 to 18 percent slopes, moderately eroded	5.1	0.1%
MtC2	Miamian-Russell silt loams, bedrock substratum, 6 to 12 percent slopes, moderately eroded	28.0	0.8%
OcA	Ockley silt loam, 0 to 2 percent slopes	10.0	0.3%
RdB	Raub silt loam, 2 to 6 percent slopes	3.4	0.1%
Rn	Ross loam	10.9	0.3%
RvB	Russell-Miamian silt loams, 2 to 6 percent slopes	113.8	3.3%
RvB2	Russell-Miamian silt loams, 2 to 6 percent slopes, moderately eroded	88.1	2.5%
RxB	Russell-Urban land complex, gently sloping	59.4	1.7%
Ud	Udorthents	44.5	1.3%
W	Water	215.6	6.2%
WyB	Wynn silt loam, 2 to 6 percent slopes	6.4	0.2%
WyC2	Wynn silt loam, 6 to 12 percent slopes, moderately eroded	19.6	0.6%
XeA	Xenia silt loam, 0 to 2 percent slopes	5.1	0.1%
XeB	Xenia silt loam, 2 to 6 percent slopes	26.9	0.8%
XeB2	Xenia silt loam, 2 to 6 percent slopes, moderately eroded	27.0	0.8%
Subtotals for Soil Survey Area		978.9	28.2%
Totals for Area of Interest		3,488.6	100.0%

Preble County, Ohio (OH135)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CyA	Cyclone silt loam, 0 to 2 percent slopes	15.3	0.4%
DaB	Dana silt loam, 2 to 6 percent slopes	8.8	0.3%
EeA	Eel silt loam, gravelly substratum, 0 to 1 percent slopes, occasionally flooded	10.3	0.3%
EgB	Eldean gravelly loam, 2 to 6 percent slopes	16.0	0.5%
EhC3	Eldean gravelly clay loam, 6 to 12 percent slopes, severely eroded	25.3	0.7%
EkB	Eldean loam, 2 to 6 percent slopes	69.2	2.0%
EkB2	Eldean loam, 2 to 6 percent slopes, eroded	4.7	0.1%
FcA	Fincastle silt loam, 0 to 2 percent slopes	55.8	1.6%
HeF2	Hennepin-Miamian silt loams, 25 to 50 percent slopes, eroded	434.4	12.5%
HwE2	Hennepin-Wynn silt loams, 18 to 25 percent slopes, eroded	31.2	0.9%
MeC2	Miamian silt loam, 6 to 12 percent slopes, eroded	206.3	5.9%
MeD2	Miamian silt loam, 12 to 18 percent slopes, eroded	43.0	1.2%
MhC3	Miamian-Losantville clay loams, 6 to 12 percent slopes, severely eroded	110.3	3.2%
MhD3	Miamian-Losantville clay loams, 12 to 18 percent slopes, severely eroded	74.5	2.1%
MmE2	Miamian-Hennepin silt loams, 18 to 25 percent slopes, eroded	171.1	4.9%
MnE3	Miamian-Hennepin clay loams, 18 to 25 percent slopes, severely eroded	10.0	0.3%
OcA	Ockley silt loam, 0 to 2 percent slopes	34.2	1.0%
OcB	Ockley silt loam, 2 to 6 percent slopes	29.6	0.9%
RaB	Rainsville silt loam, 2 to 6 percent slopes	14.1	0.4%
RaB2	Rainsville silt loam, 2 to 6 percent slopes, eroded	4.8	0.1%
RoE2	Rodman-Kendallville complex, 18 to 25 percent slopes, eroded	2.2	0.1%
RpA	Rossburg silt loam, moderately wet, sandy substratum, 0 to 1 percent slopes, occasionally flooded	53.2	1.5%
RuB	Russell-Miamian silt loams, 2 to 6 percent slopes	160.2	4.6%
RuB2	Russell-Miamian silt loams, 2 to 6 percent slopes, eroded	183.2	5.3%
StA	Stonelick loam, gravelly substratum, 0 to 1 percent slopes, frequently flooded	167.4	4.8%
ThA	Thackery silt loam, 0 to 2 percent slopes	2.9	0.1%
W	Water	392.1	11.3%
WnA	Westland silt loam, 0 to 2 percent slopes	11.4	0.3%
WyB	Wynn silt loam, 2 to 6 percent slopes	11.9	0.3%
WyC2	Wynn silt loam, 6 to 12 percent slopes, eroded	16.0	0.5%
XeA	Xenia silt loam, 0 to 2 percent slopes	20.0	0.6%

Preble County, Ohio (OH135)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
XeB	Xenia silt loam, 2 to 6 percent slopes	72.3	2.1%
XeB2	Xenia silt loam, 2 to 6 percent slopes, eroded	29.9	0.9%
Subtotals for Soil Survey Area		2,491.6	71.8%
Totals for Area of Interest		3,468.5	100.0%

Map Unit Descriptions (Hueston Woods State Park)

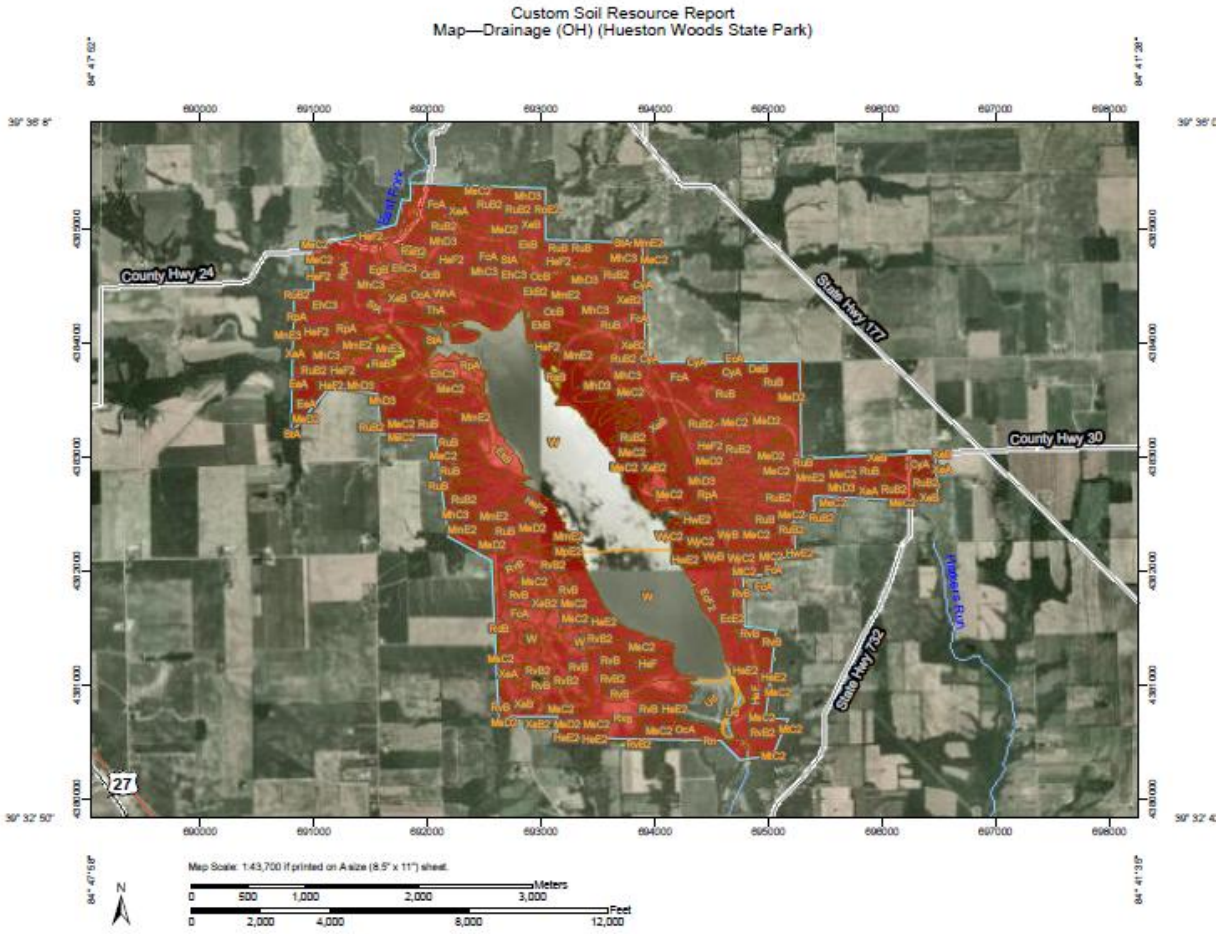
The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

(U.S. Department of Agriculture 2013).



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Soil Ratings
- Very limited
- Somewhat limited
- Not limited
- not rated or not available

Political Features
- Cities

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:43,700 if printed on A size (8.5" x 11") sheet.

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:15,840.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Butler County, Ohio
Survey Area Data: Version 11, Oct 3, 2012

Soil Survey Area: Preble County, Ohio
Survey Area Data: Version 11, Jan 27, 2010

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: 6/23/2004

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

APPENDIX H. NATURAL HERITAGE DATABASE DATA REQUEST FORM

(OhioDepartment of Natural Resources 2012, 2)

DATA REQUEST FORM

OHIO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
OHIO NATURAL HERITAGE PROGRAM
2045 MORSE RD., BLDG. G-3
COLUMBUS, OHIO 43229-6693
PHONE: 614-265-6452; EMAIL: obdrequest@dnr.state.oh.us

INSTRUCTIONS:
Please complete both pages of this form, sign and return it to the address or email address above along with: **(1)** a brief letter describing your project, and **(2)** a map detailing the boundaries of your project site. A copy of the pertinent portion of a USGS 7.5 minute topographic map is preferred but other maps are acceptable. Data requests will be competed within approximately 30 days. If you email your request you do not need to mail the original unless otherwise requested.

FEES:
As of June 2010, we have temporarily suspended charging a fee until a review of the data request process has been completed.

WHAT WE PROVIDE: The Natural Heritage Database is the most comprehensive source of information on the location of Ohio's rare species and significant natural features. Records for the following will be provided: plants and animals (state and federal listed species), high quality plant communities, geologic features, breeding animal concentrations and unprotected significant natural areas. We also provide locations for managed areas including federal, state, county, local and non-profit sites, as well as state and national scenic rivers. A minimum one mile radius around the project site will automatically be searched. Because the data is sensitive information, it is our policy to provide only the data needed to complete your project.

****

Date: _____ Company name: _____

Name of person response letter should be addressed to: Mr. ☐ Ms. ☐

_____

Address: _____

City/State/Zip: _____

Phone: _____ Fax: _____

E-mail address: _____

Project Name: _____

Project Number: _____

APPENDIX I. PREBLE COUNTY, OHIO STATE LISTED SPECIES

(Ohio Department of Natural Resources 2012, 2)

Ohio Division of Wildlife
Natural Heritage Database
State-listed Species for Preble Co.
As of 11/8/2012

Last Recorded	Scientific Name	Common Name	State Status	Federal Status
PLANTS				
1988	*Carex mesochorea*	Midland Sedge	T	
1981	*Ptychomitrium drummondii*	Drummond's Ptychomitrium	X	
2003	*Triphora trianthophora*	Three-birds Orchid	P	
2004	*Viburnum molle*	Soft-leaved Arrow-wood	T	
ANIMALS				
1970	*Clonophis kirtlandii*	Kirtland's Snake	T	FSC
1987	*Coragyps atratus*	Black Vulture	SC	
2005	*Etheostoma microperca*	Least Darter	SC	
2004	*Myotis sodalis*	Indiana Bat	E	FE
2005	*Orconectes sloanii*	Sloan's Crayfish	T	

P=Potentially Threatened, T=Threatened, E=Endangered, SC=Species of Concern
SI=Special Interest, FT=Federally Threatened, FE=Federally Endangered,
F=Federal Only

Page 1 of 1

(Ohio Department of Natural Resources 2013)

Ohio Division of Wildlife
Natural Heritage Database
State-listed Species for Butler Co.
As of 11/8/2012

Last Recorded	Scientific Name	Common Name	State Status	Federal Status
PLANTS				
1965	*Arabis pycnocarpa var. adpressipilis*	Southern Hairy Rock Cress	P	
1990	*Arabis pycnocarpa var. pycnocarpa*	Western Hairy Rock Cress	X	
2011	*Bromus kalmii*	Prairie Brome	P	
2005	*Carex mesochorea*	Midland Sedge	T	
2011	*Carex timida*	Timid Sedge	T	
1961	*Cuscuta pentagona*	Five-angled Dodder	T	
2000	*Cyperus acuminatus*	Pale Umbrella-sedge	P	
2008	*Echinodorus berteroi*	Burhead	T	
2001	*Ribes missouriense*	Missouri Gooseberry	T	
1991	*Salix caroliniana*	Carolina Willow	P	
2006	*Silene nivea*	Snowy Campion	E	
2009	*Viburnum molle*	Soft-leaved Arrow-wood	T	
ANIMALS				
1987	*Bartramia longicauda*	Upland Sandpiper	E	
1991	*Clonophis kirtlandii*	Kirtland's Snake	T	FSC
1989	*Eurycea lucifuga*	Cave Salamander	E	
1975	*Exoglossum laurae*	Tonguetied Minnow	T	
2008	*Falco peregrinus*	Peregrine Falcon	T	FSC
1995	*Gomphus externus*	Plains Clubtail	E	
2010	*Haliaeetus leucocephalus*	Bald Eagle	F	FSC
1991	*Ixobrychus exilis*	Least Bittern	T	
2000	*Ladona deplanata*	Blue corporal	E	
1988	*Myotis sodalis*	Indiana Bat	E	FE
1990	*Nycticorax nycticorax*	Black-crowned Night-heron	T	
2005	*Orconectes sloanii*	Sloan's Crayfish	T	
1990	*Porzana carolina*	Sora Rail	SC	

P=Potentially Threatened, T=Threatened, E=Endangered, SC=Species of Concern
SI=Special Interest, FT=Federally Threatened, FE=Federally Endangered,
F=Federal Only

Page 1 of 1

APPENDIX K. SURVEY PROCESS

Qualtrics is the survey design site that the project team decided to use as a tool to develop the survey and deliver it to HWSP's Facebook page. Miami University has a contract with Qualtrics, and the program would allow the project team to abide by the Institutional Review Board requirements. A specific feature that was important in deciding to use Qualtrics was the ability to administer the survey in such a way that the subjects' information would not be identifiable. Qualtrics will separate each participant's personal information, such as IP address from their response automatically. Once the data is collected, Qualtrics has a security measure in place to prevent unauthorized access to the data and the data can only be accessed by team members. The Qualtrics survey design was set up as an anonymous survey link to ensure anonymity. Additionally, the survey design was set up so respondents are not forced to answer any of the questions and can leave the survey at any point. An informed consent and query asking the participants if they are over the age of 18 must be answered at the beginning of the survey for the participants to continue. This is to ensure that they understand their rights and to prevent minors from participating in the survey.

The survey was posted by Amanda Dalton, the social media representative at HWSP in early February and was reposted in early March. This message was included with the survey link: "Let Us Know Your Thoughts! Do you bike or walk at Hueston Woods State Park? Are you 18 or older? If you answered yes to both then please help us out by taking our quick survey. It only takes a minute, is completely voluntary and completely anonymous. And it may help us to improve the park!"

APPENDIX L. INFORMATIONAL PARAGRAPH

Dear Participant:

This survey is being conducted by a small group of Miami University graduate students within The Institute for the Environment and Sustainability (IES). Our advisors include Suzi Zazycki, Outreach Coordinator for IES, and Thomas Crist, Director of IES and Professor of Zoology.

You are invited to participate in a research survey of the safety and recreational value of various trails at Hueston Woods State Park. I will ask you to complete a short questionnaire, approximately 5 minutes long, about what you think of different aspects of the park. You will complete the survey online through the Qualtrics program. You will not be asked to include your name on any of the questionnaires, thus your answers cannot be associated with you. Nonetheless, the questionnaires will be treated as confidential information, stored in a secure location for the duration of the project, accessed only by the research group and advisors, and destroyed after the data has been analyzed. All faculty and staff who use the Qualtrics tool are provided space on a dedicated Survey Data Storage Server for storing data resulting from surveys conducted using these surveys tools. Therefore, all information collected will be highly secured.

Although every effort will be done to ensure confidentiality of your responses, all Internet-based communication is subject to the remote likelihood of tampering from an outside source. IP addresses will not be investigated and data will be removed from the server.

The responses you provide today are being collected with software that is designed to secure your data and provide you with confidentiality. Nevertheless, despite these safeguards, there is always a remote possibility of hacking or other security breaches that could compromise the confidentiality of the information you provide. Thus, you should remember that you are free to decline to answer any question that makes you uncomfortable for any reason.

Your participation is voluntary and you may withdraw from the survey at any time or decline to answer any questions that make you uncomfortable. You will not be asked to do anything that exposes you to risks beyond those of everyday life. The benefit of the study, scientifically, is it will help us understand more about what people think of the safety of pedestrians and bike riders at Hueston Woods State Park. The generalized results may be presented at professional conferences or published in articles describing the results of the research.

If you have further questions about the study, please contact Suzi Zazycki, at zazycks@muohio.edu. If you have questions about your rights as a research participant, please call the Office of Advancement of Research and Scholarship at 529-3600 or email: humansubjects@muohio.edu.

Thank you for your participation. We are very grateful for your help and hope that this will be an interesting session for you.

By clicking “Continue to Survey” below, you agree to participate in the survey of your opinions on pedestrian and bike rider safety at Hueston Woods State Park. By doing so, you are stating that you understand your participation is voluntary and that your name will not be associated with your responses. By clicking “Continue to Survey” below, you acknowledge that you are 18 years or older.

“Continue to Survey”

Dear Participant:

This focus group is being conducted by a small group of Miami University graduate students within The Institute for the Environment and Sustainability (IES). Our advisors include Suzi Zazycki, Outreach Coordinator for IES, and Thomas Crist, Director of IES and Professor of Zoology.

You are invited to participate in this focus group to assist us in enhancing the safety and recreational value of various trails at Hueston Woods State Park (HWSP). We will be asking you about your opinions on various facets of constructing a bikeway along Main Loop Road. Your opinions will be treated as confidential information, stored in a secure location for the duration of the project, accessed only by the research group and advisors, and destroyed after the data has been analyzed. Your participation is voluntary and you may withdraw from the focus group at any time or decline to answer any questions that make you uncomfortable. You will not be asked to do anything that exposes you to risks beyond those of everyday life. The benefit of the study, scientifically, is it will help us understand the feasibility of creating a safe bikeway at HWSP. The generalized results may be presented at professional conferences or published in articles describing the results of the research.

If you have further questions about the focus group, please contact Suzi Zazycki, at zazycks@muohio.edu. If you have questions about your rights as a research participant, please call the Office of Advancement of Research and Scholarship at 529-3600 or email: humansubjects@muohio.edu.

Thank you for your participation. We are very grateful for your help and hope that this will be an interesting session for you. You may keep this portion of the page.

Cut at the line, keep the top section and return the bottom section.

I agree to participate in the focus group about the feasibility of constructing a bikeway at Hueston Woods State Park. I understand my participation is voluntary and that my name will not be associated with my responses. By signing below, I acknowledge that I am 18 years or older.

Participant's signature _____ Date:_____

APPENDIX N. HWSP PUBLIC SURVEY

HWSP park visitor survey

Q13 Hueston Woods State Park Visitor Survey Regarding Preferred Mode of Transportation in the Park Conducted in coordination with Miami University, Institute for the Environment and Sustainability Information About the Survey: You are invited to participate in this brief survey that is designed to help Hueston Woods State Park (HWSP) better understand what mode of travel visitors use within the park, particularly around Main Loop Road. This survey is being conducted by students in the Institute for the Environment and Sustainability at Miami University on behalf of and with the permission of HWSP. The survey is part of a research project designed to help HWSP plan better opportunities for travel within the park. Consent to Participate: Your opinions will be treated as confidential information, stored in a secure location for the duration of the project, accessed only by the research group and advisors, and destroyed after the data has been analyzed. Your participation is voluntary and you may stop taking the survey at any time or decline to answer any questions. You will not be asked to do anything that exposes you to risks beyond those of everyday life. The generalized results may be presented at professional conferences or published in articles describing the results of the research. If you have further questions about this research, please contact Suzi Zazycki, at zazycks@muohio.edu. If you have questions about your rights as a research participant, please call the Office of Advancement of Research and Scholarship at 529-3600 or email: humansubjects@muohio.edu. I agree to participate in the survey about my reasons for visiting Hueston Woods State Park and how I travel around the park. I understand my participation is voluntary and that my name will not be associated with my responses.

- ❑ Yes (1)
- ❑ No (2)

If No Is Selected, Then Skip To End of Survey

Q14 You must be of 18 years or older to participate in this survey. By checking yes below, I acknowledge that I am 18 years or older.

- ❑ Yes (1)
- ❑ No (2)

If No Is Selected, Then Skip To End of Survey

Q1 1) When you visit Hueston Woods State Park, do you come to exercise?

- ❍ All of the Time (1)
- ❍ Often (2)
- ❍ Sometimes (3)
- ❍ Rarely (4)
- ❍ Never (5)

Q2 2) When you visit Hueston Woods State Park, do you come to bike or walk?

- ❍ All of the Time (1)
- ❍ Often (2)
- ❍ Sometimes (3)
- ❍ Rarely (4)
- ❍ Never (5)

Q3 3) How do you tend to travel from one part of the park to another?

- ❍ Bicycle (1)
- ❍ Walk (2)
- ❍ Car (3)
- ❍ Other (4) _____

Q4 4) If you travel around the park without a motor vehicle, how satisfied are you with getting around the park?

- ❍ Very Satisfied (1)
- ❍ Satisfied (2)
- ❍ Somewhat Satisfied (3)
- ❍ Neutral (4)
- ❍ Somewhat Dissatisfied (5)
- ❍ Dissatisfied (6)
- ❍ Very Dissatisfied (7)

Q5 5) Have you biked or walked along the Main Loop Road?

- ❍ Frequently (1)
- ❍ Occasionally (2)
- ❍ Not At All (3)

If Not At All Is Selected, Then Skip To 8) Do you have any additional comment...

Q6 6) If you answered "Frequently" or "Occasionally" for question 5 have you had any safety concerns or incidents?

- ❍ Yes (1)
- ❍ Maybe (2)
- ❍ No (3)

Q7 7) Do you agree with this statement: "I feel safe biking or walking along the shoulder of the Main Loop Road in the park."

- ❍ Strongly Agree (1)
- ❍ Agree (2)
- ❍ Neither Agree nor Disagree (3)
- ❍ Disagree (4)
- ❍ Strongly Disagree (5)
- ❍ I do not bike or walk around the Main Loop Road (6)

Q16 8) Do you have any additional comments or suggestions?

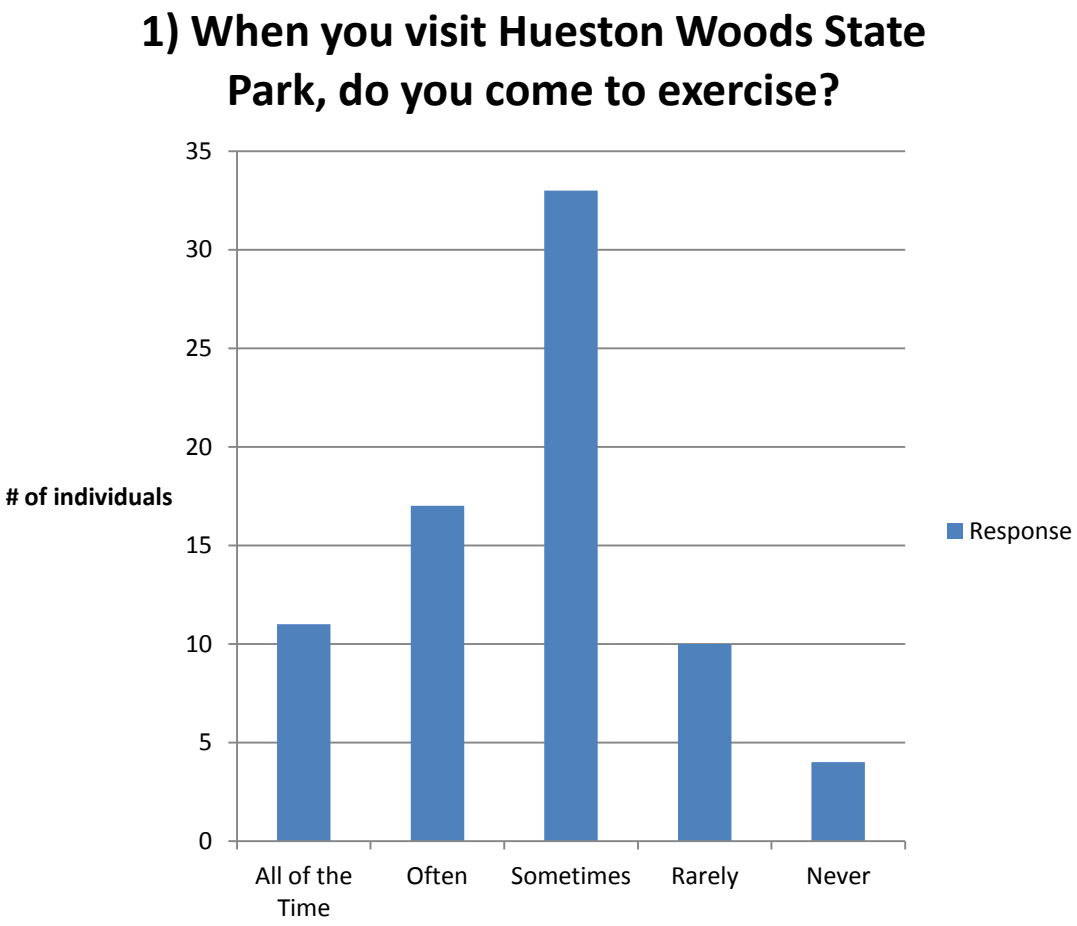


Figure 1. Question 1 of HWSP survey

Table 1. When you visit Hueston Woods State Park, do you come to exercise?

#	Answer		Response	%
1	All of the Time		11	15%
2	Often		17	23%
3	Sometimes		33	44%
4	Rarely		10	13%
5	Never		4	5%
	Total		75	100%

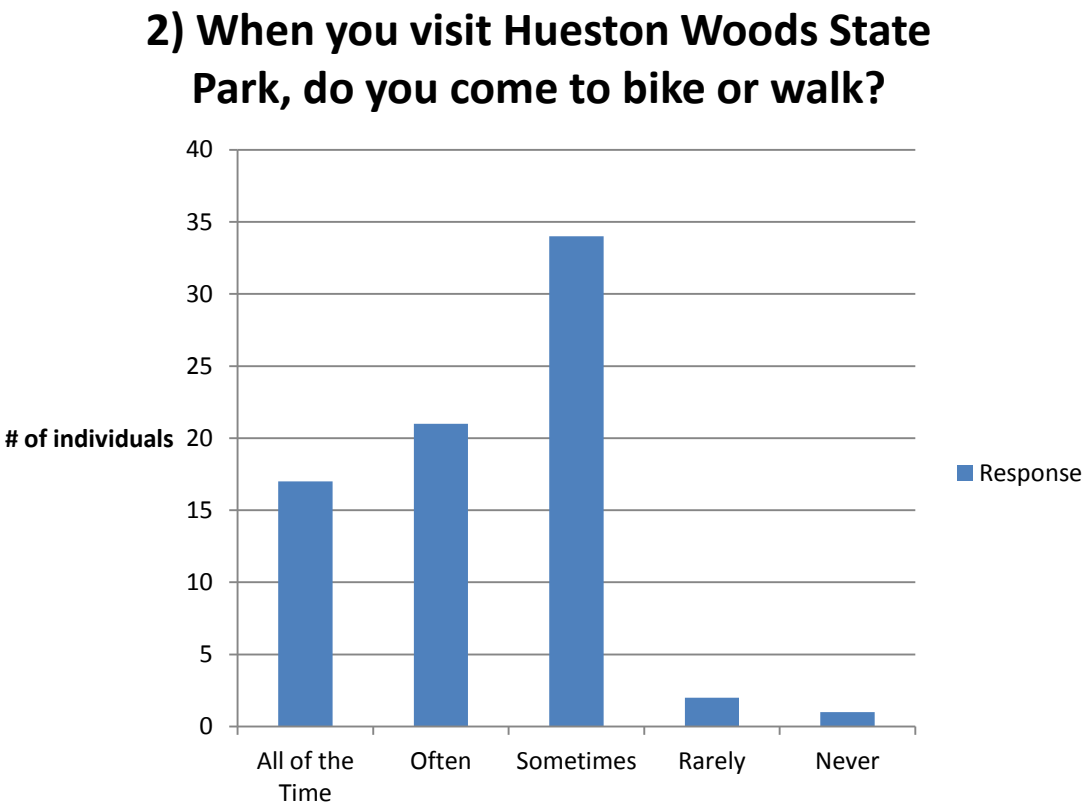


Figure 2. Question 2 of HWSP survey

Table 2. When you visit Hueston Woods State Park, do you come to bike or walk?

#	Answer		Response	%
1	All of the Time		17	23%
2	Often		21	28%
3	Sometimes		34	45%
4	Rarely		2	3%
5	Never		1	1%
	Total		75	100%

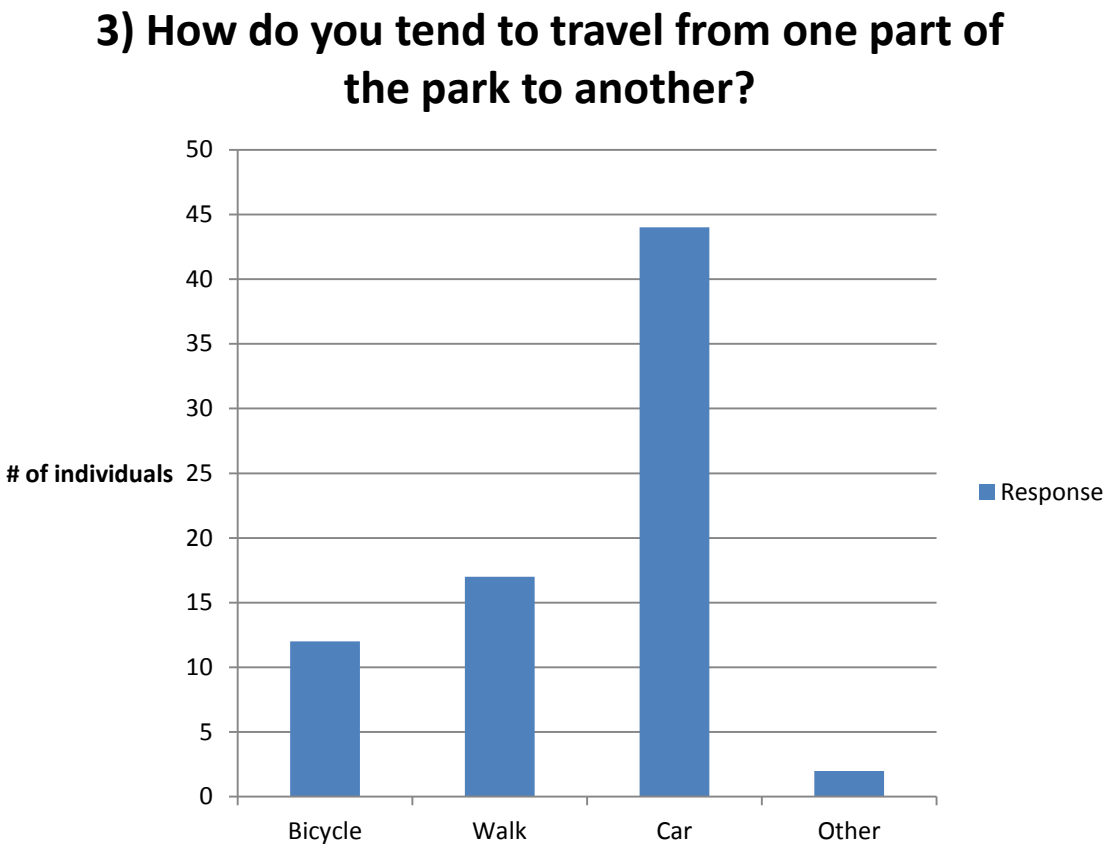


Figure 3. Question 3 of HWSP survey

Table 3. How do you tend to travel from one part of the park to another?

#	Answer		Response	%
1	Bicycle		12	16%
2	Walk		17	23%
3	Car		44	59%
4	Other		2	3%
	Total		75	100%

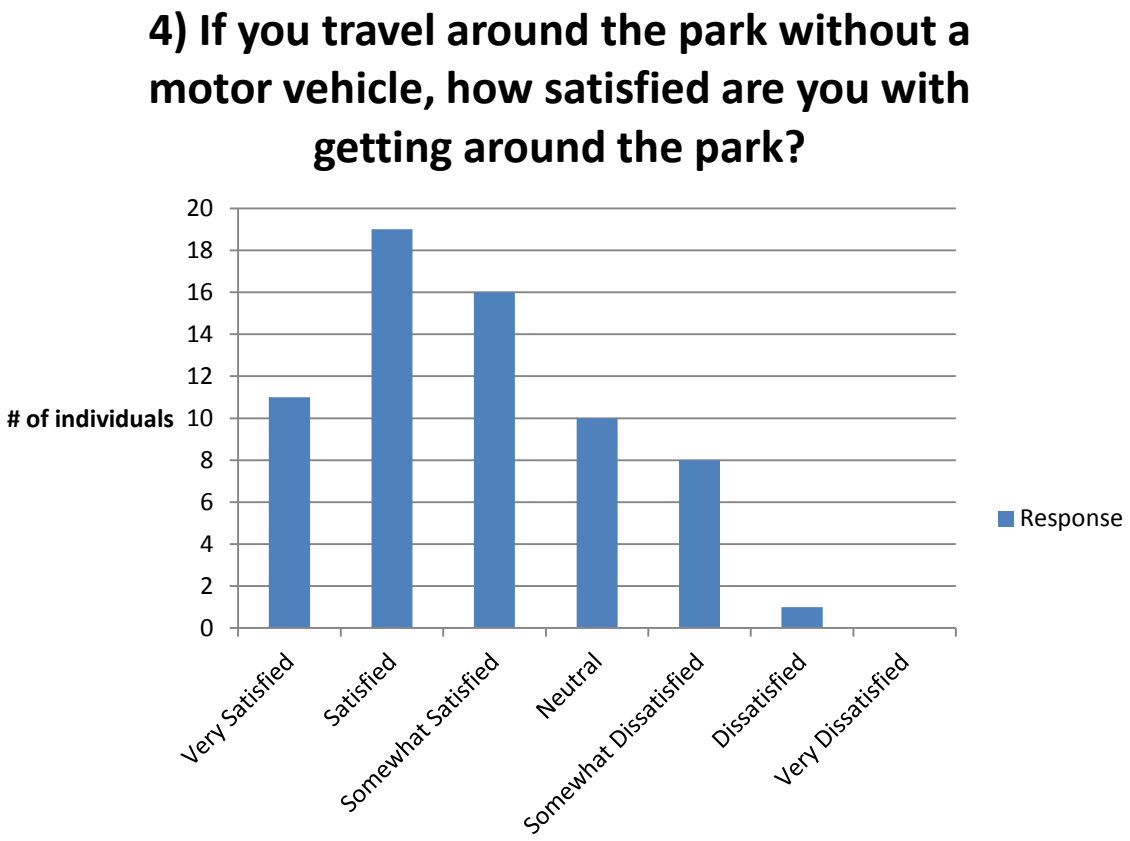


Figure 4. Question 4 of HWSP survey

Table 4. If you travel around the park without a motor vehicle, how satisfied are you with getting around the park?

#	Answer		Response	%
1	Very Satisfied		11	17%
2	Satisfied		19	29%
3	Somewhat Satisfied		16	25%
4	Neutral		10	15%
5	Somewhat Dissatisfied		8	12%
6	Dissatisfied		1	2%
7	Very Dissatisfied		0	0%
	Total		65	100%

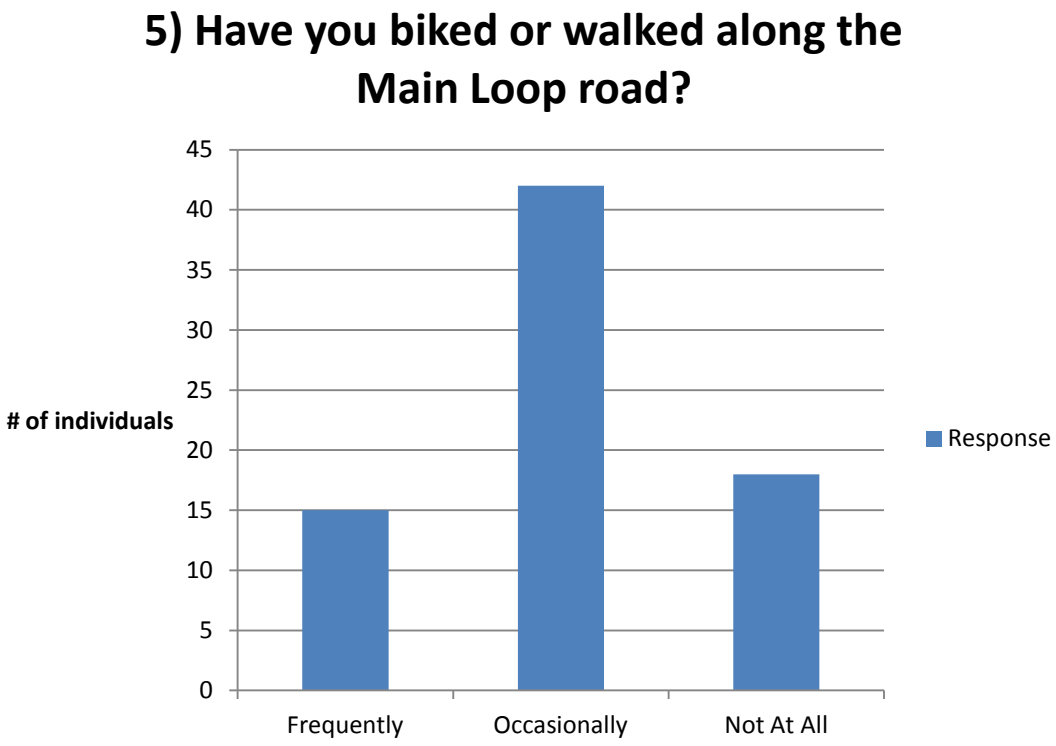


Figure 5. Question 5 of HWSP survey

Table 5. Have you biked or walked along the Main Loop Road?

#	Answer		Response	%
1	Frequently		15	20%
2	Occasionally		42	56%
3	Not At All		18	24%
	Total		75	100%

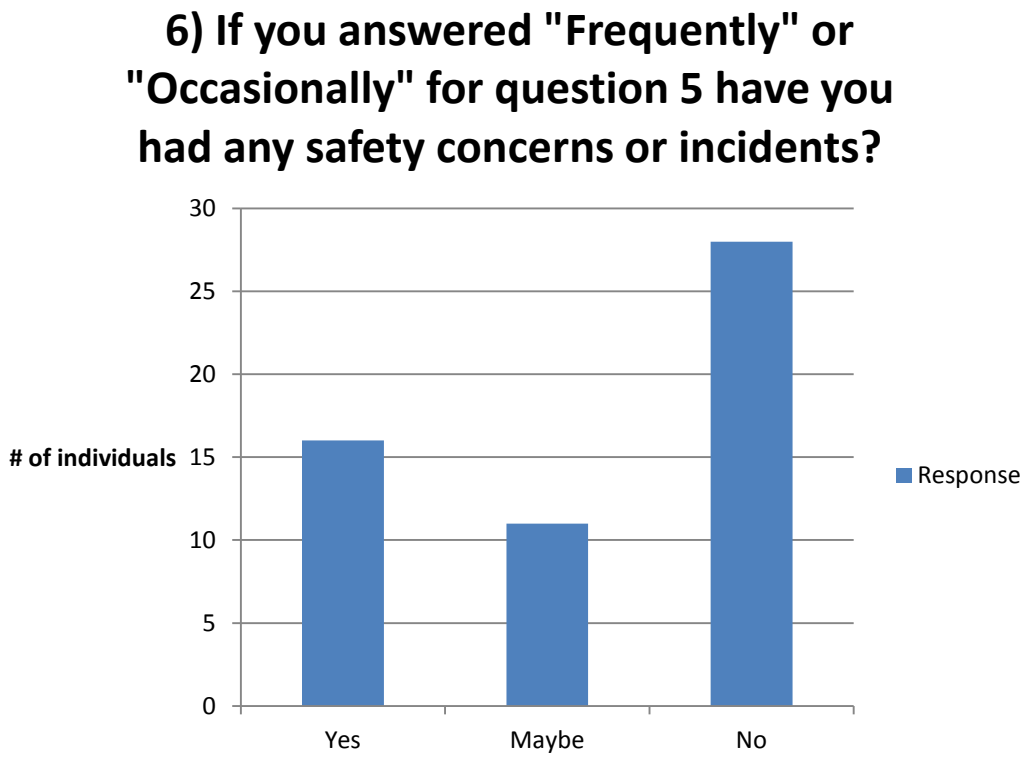


Figure 6. Question 6 of HWSP survey

Table 6. If you answered "Frequently" or "Occasionally" for question 5 have you had any safety concerns or incidents?

#	Answer		Response	%
1	Yes		16	29%
2	Maybe		11	20%
3	No		28	51%
	Total		55	100%

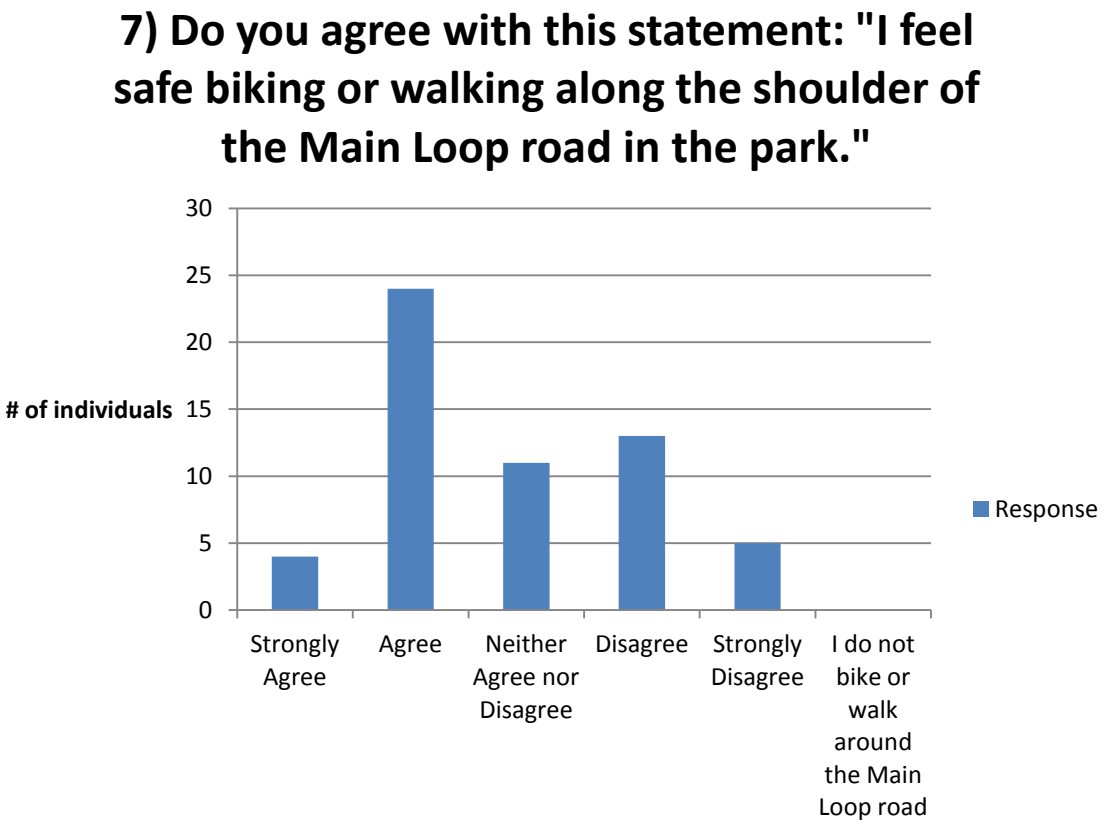
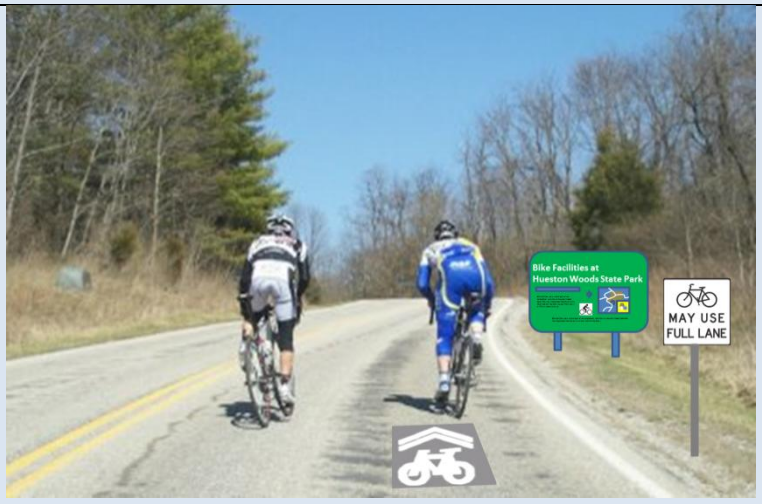


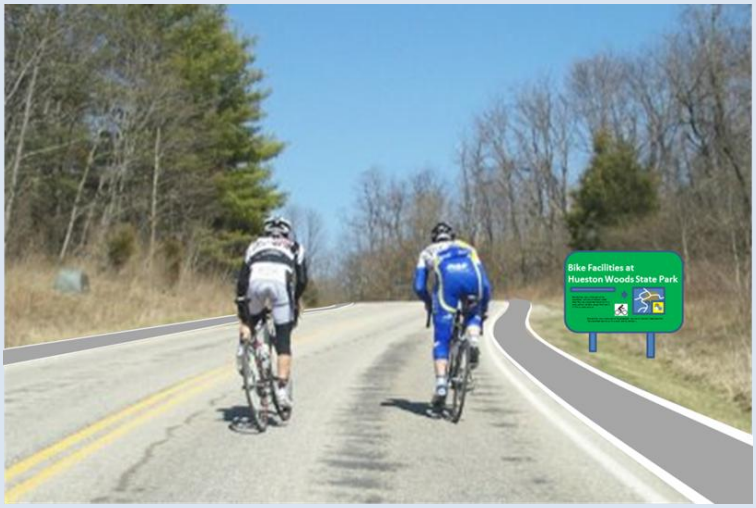
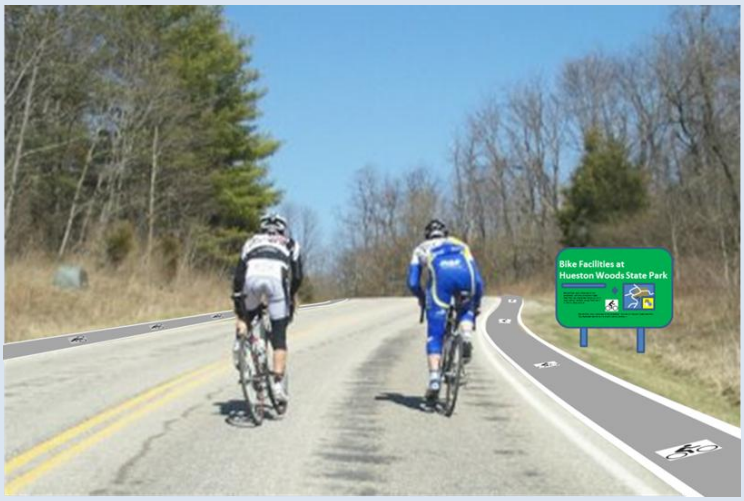
Figure 7. Question 7 of HWSP survey

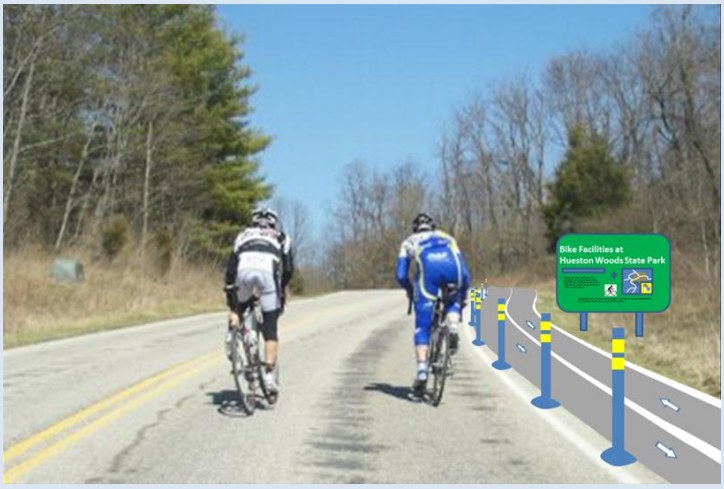
Table 7. Do you agree with this statement: "I feel safe biking or walking along the shoulder of the Main Loop Road in the park."

#	Answer		Response	%
1	Strongly Agree		4	7%
2	Agree		24	42%
3	Neither Agree nor Disagree		11	19%
4	Disagree		13	23%
5	Strongly Disagree		5	9%
6	I do not bike or walk around the Main Loop Road		0	0%
	Total		57	100%

APPENDIX P. BIKEWAY ALTERNATIVES TABLE

Alternatives	Summary	Example
Maintain shared lanes	• Bicyclists are expected to ride with traffic in the vehicle lane. Shoulder width varies, but is not wide enough to accommoda-te bicyclists.	
Add shared-lane markings, signage, & bicycle education program	• Addition of shared-lane markings • Addition of bicycle related signs • Bicycle Safety education provided by HWSP	
Shared lane (wide outside lanes)	• Not considered: recommende d for roads with >3,000 vehicles per day	No image available.

Paved shoulders	• Addition of bicycle related signs • Bicycle safety education provided by HWSP • Widening the road on both sides to have bicyclists ride outside the vehicle lane	
Bike lanes	• Addition of bicycle related signs • Bicycle safety education provided by HWSP • Widening the road to have bicyclists ride outside the vehicle lane • Addition of bike lane symbol	
Bicycle boulevards	• Not considered: recommended for residential roadways, and where speed is <25 mph and seeks to deter vehicular	No image available.

	traffic	
Shared use path: independent right of way	• Not considered: recommended when the bikeway is not adjacent or near a road, such as Miami Whitewater or a Rails to Trails bikeway	No image available.
Shared use path: adjacent to the road (sidepath)	• Addition of bicycle related signs • Bicycle safety education provided by HWSP • Widening the road to have bicyclists ride outside the vehicle lane • Must meet ADA guidelines because it's a multi-use path • Either requires a separation of 5 feet from the road or a barrier between the road and the path.	

APPENDIX Q. BICYCLE LEVEL-OF-SERVICE CALCULATIONS AND PAVEMENT CONDITION RATINGS

(Sprinkle Consulting 2013)

To assist in analyzing the various bikeway alternatives, the project team utilized a bicycle level of service calculator. The Highway Capacity Manual (HCM) defines Levels-of-Service (LOS) as "...qualitative measures that characterize operational conditions within a traffic stream and their perception by motorists and passengers." (Transportation Research Board 2010). It is a nationally-used measure of on-road bicyclist comfort level based on the roadway's geometry and traffic conditions (Sprinkle Consulting 2013). The HCM defines six levels of service, ranging from A to F, calculated from the output from a mathematical model based on multiple performance measures. The Level-of-Service scores and compatibility levels can be seen in the table below. LOS A represents the best operating conditions from the traveler's perspective and LOS F the worst. (Transportation Research Board 2010).

LEVEL OF SERVICE SCORES

Level-of-Service	BLOS Score	Compatibility Level
A	≤1.5	Extremely High
B	>1.5 and ≤2.5	Very High
C	>2.5 and ≤3.5	Moderately High
D	>3.5 and ≤4.5	Moderately Low
E	>4.5 and ≤5.5	Very Low
F	>5.5	Extremely Low

Utilizing the LOS calculation from the Highway Capacity Manual, Sprinkle Consulting and The League of Illinois Bicyclists developed an online Bicycle Level-of-Service Calculator (BLOS) (Sprinkle Consulting 2013). The project team used this online calculator to determine BLOS scores for each alternative. A visual of the inputs and scores for each alternative as well as a description of the pavement condition ratings can be found below. The input information for the current roadway is as follows:

INPUT AND THEIR SOURCE FOR BLOS CALCULATOR

Source	Input	
Current Road Condition	Through lanes per direction:	1
Minimum Road Width from Current Road Condition	Width of outside travel lane, to outside stripe (in feet):	9
Current Road Condition	Paved shoulder, bike lane, OR marked parking area, outside lane stripe to pavement edge (in feet):	0
ODOT Traffic Count Data (found in Appendix R)	Bi-directional Traffic Volume (in ADT):	983
Model Parameter Range (as seen in Figure below)	Percentage of Heavy Vehicles:	2
Model Parameter Range (as seen in Figure below)	FHWA's pavement condition rating (definitions can be found in below):	4
Current Road Condition	Percentage of road segmented with occupied on-street parking:	0

BLOS Data Input Fields

The following provides further information on the BLOS data inputs. See the references for more.

Roadway parameters will often change, and averaging could be done depending on the situation. In general, try to select a typical cross-section.

Through lanes per direction:	Do not include medians, turn lanes, or continuous-left-turn lanes.
Width of outside travel lane, to outside stripe (in feet):	Width of right-most travel lane, excluding striped paved shoulders, bike lanes, and marked parking stalls.
Paved shoulder, bike lane, OR marked parking area, outside lane stripe to pavement edge (in feet):	Besides a paved shoulder or a bike lane, this width may also be marked (striped or hashed) parking stalls. For diagonal parking, use the perpendicular distance from the end of the parking stripes to the pavement edge. This calculator does not work when there are BOTH bike lanes and parking stalls - please see the reference for this case.
Bi-directional Traffic Volume (in ADT):	Daily average. Assumed Directional factor (0.565) and Peak Hour Factor (0.091) values are used in a conversion to peak 15-minute volume.
Percentage of heavy vehicles:	As defined in the Highway Capacity Manual.
FHWA's pavement condition rating:	For a longer term view normalizing the point at which a road is in its repavement cycle, use 4 as an average.
Percentage of road segment with occupied on-street parking:	Exclude driveways. Either one side or an average of both sides may be considered at a time.

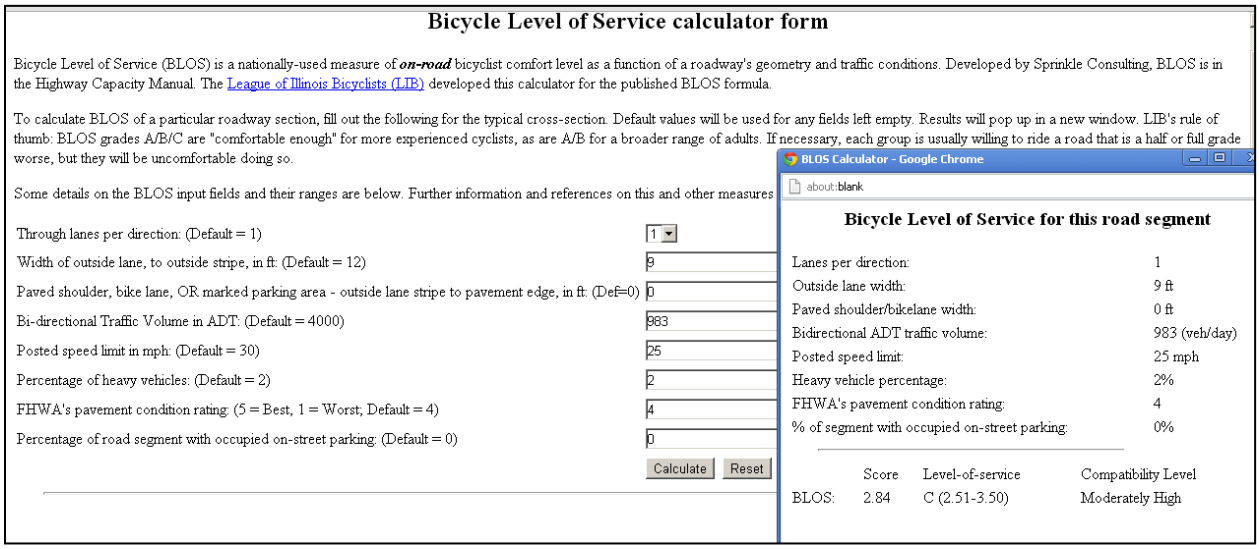
Model parameter ranges

The BLOS model was developed using roads with the following parameter ranges:

- Through lanes per direction - 1 to 3 (2 to 6 lane roads)
- Width of outside travel lane, to outside stripe - 10 to 16 feet
- Paved shoulder or bike lane, outside lane stripe to pavement edge - 0 to 6 feet (no rumble strips)
- Bi-directional traffic volume - 550 to 36,000 ADT (Average Daily Traffic)
- Posted speed limit - 25 to 50 mph
- Percentage of heavy vehicles - 0 to 2%
- FHWA's pavement condition rating - 5 (very good) to 2 (poor)
- A wide range of development types and parking conditions

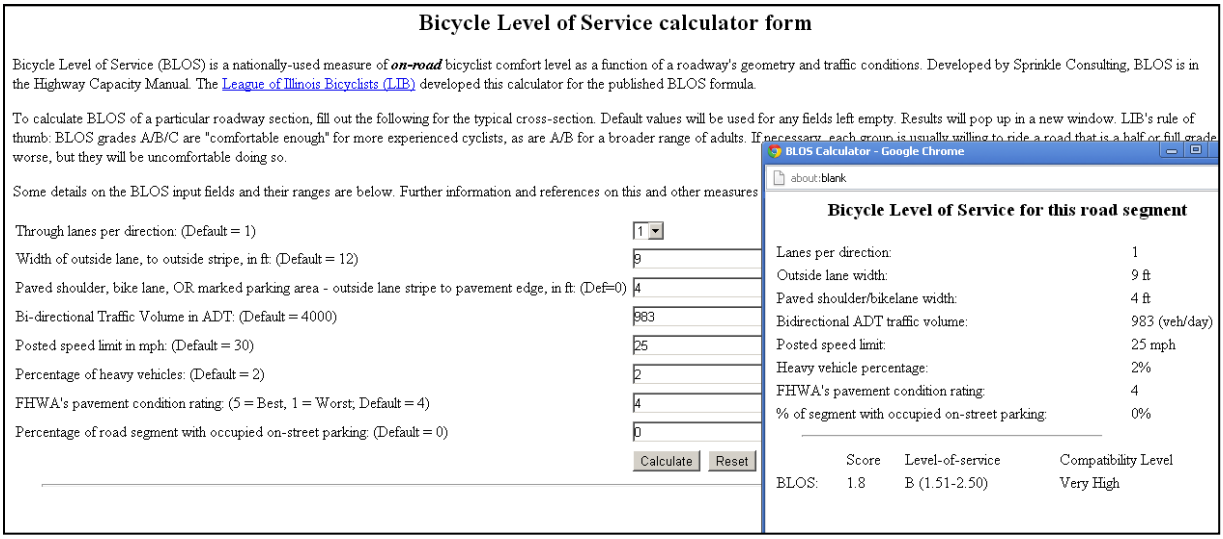
BIKEWAY ALTERNATIVE 1 AND 2: MAINTAIN SHARED LANES AND ADD SHARED LANE MARKINGS, SIGNAGE AND A BICYCLE EDUCATION PROGRAM (MARKED SHARED LANES)

At the default pavement condition rating of 4, the present state of the roadway (as a shared roadway) has a BLOS of 2.84 (C), which is a "moderately high" compatibility level of service for bicyclists. If the Pavement Condition Rating is a 3 or above, the present state of the road has a "moderately high" level (Sprinkle Consulting 2013). This is evidence to the "maintain shared lanes" alternative to keep the road in its current state. If the pavement condition rating falls below a 3, the level of service for bicyclists and vehicles falls to "moderately low" and a new alternative should be considered.



ALTERNATIVE 3 AND 4: ROADWAY PLUS A 4 FOOT PAVED SHOULDER/ BIKE LANE:

Based on the current conditions of the road plus a 4 foot paved shoulder or bike lane, at the default pavement condition rating of 4, the BLOS is 1.8 (B), which is a "very high" compatibility level of service for bicyclists. The BLOS would remain above a "moderately high" level of service until the pavement condition rating falls to a 1, in which the BLOS falls to 8.43 (F), which is an "extremely low" level of service for bicyclists and vehicles (Sprinkle Consulting 2013).



Bicycle Level of Service calculator form

Bicycle Level of Service (BLOS) is a nationally-used measure of ***on-road*** bicyclist comfort level as a function of a roadway's geometry and traffic conditions. Developed by Sprinkle Consulting, BLOS is in the Highway Capacity Manual. The League of Illinois Bicyclists (LIB) developed this calculator for the published BLOS formula.

To calculate BLOS of a particular roadway section, fill out the following for the typical cross-section. Default values will be used for any fields left empty. Results will pop up in a new window. LIB's rule of thumb: BLOS grades A/B/C are "comfortable enough" for more experienced cyclists, as are A/B for a broader range of adults. If necessary, each group is usually willing to ride a road that is a half or full grade worse, but they will be uncomfortable doing so.

Some details on the BLOS input fields and their ranges are below. Further information and references on this and other measures

Through lanes per direction: (Default = 1)	1
Width of outside lane, to outside stripe, in ft: (Default = 12)	9
Paved shoulder, bike lane, OR marked parking area - outside lane stripe to pavement edge, in ft: (Def=0)	4
Bi-directional Traffic Volume in ADT: (Default = 4000)	983
Posted speed limit in mph: (Default = 30)	25
Percentage of heavy vehicles: (Default = 2)	2
FHWA's pavement condition rating: (5 = Best, 1 = Worst; Default = 4)	4
Percentage of road segment with occupied on-street parking: (Default = 0)	0

Calculate Reset

BLOS Calculator - Google Chrome

about:blank

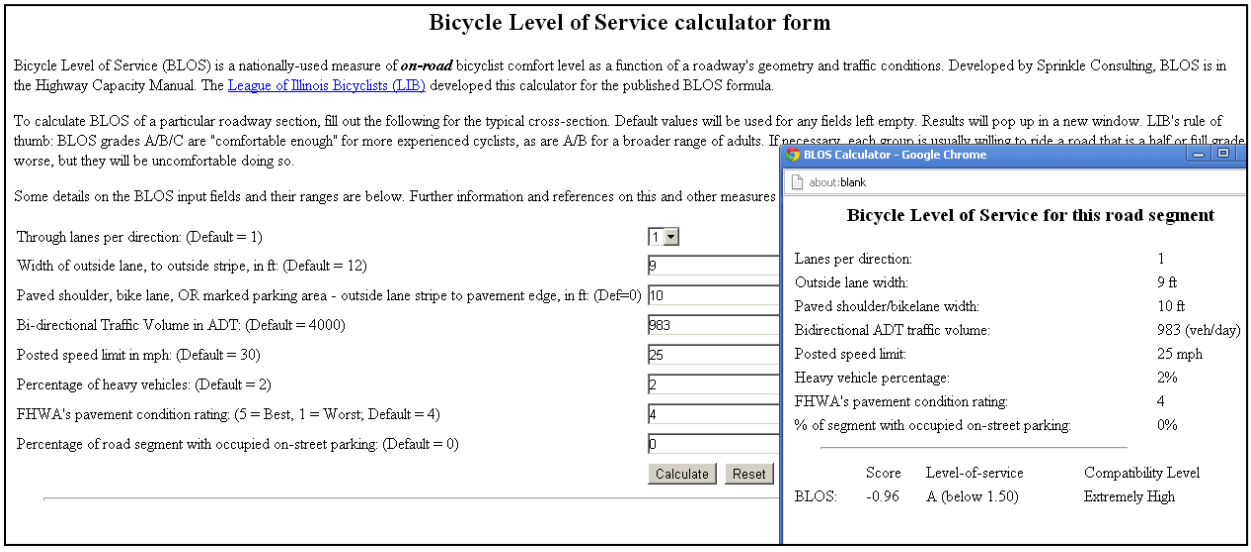
Bicycle Level of Service for this road segment

Lanes per direction:	1
Outside lane width:	9 ft
Paved shoulder/bikelane width:	4 ft
Bidirectional ADT traffic volume:	983 (veh/day)
Posted speed limit:	25 mph
Heavy vehicle percentage:	2%
FHWA's pavement condition rating:	4
% of segment with occupied on-street parking:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	1.8	B (1.51-2.50)	Very High

FOR ALTERNATIVE 5: ROADWAY PLUS A 10 FOOT SIDEPATH:

Based on the current conditions of the road, plus a 10 foot sidepath, at the default pavement condition rating of 4, the BLOS is (-0.96) (A), which is an "extremely high" compatibility level of service for bicyclists. The BLOS would remain above an "extremely high" compatibility level of service for bicyclists until the pavement condition rating is a 1, in which the BLOS falls to 5.67 (F), which is an "extremely low" compatibility level of service for bicyclists (Sprinkle Consulting 2013). However, 10 feet for the paved shoulder/bikelane width input is outside of the model parameter ranges for this calculator, therefore the numbers might be skewed.



Bicycle Level of Service calculator form

Bicycle Level of Service (BLOS) is a nationally-used measure of ***on-road*** bicyclist comfort level as a function of a roadway's geometry and traffic conditions. Developed by Sprinkle Consulting, BLOS is in the Highway Capacity Manual. The League of Illinois Bicyclists (LIB) developed this calculator for the published BLOS formula.

To calculate BLOS of a particular roadway section, fill out the following for the typical cross-section. Default values will be used for any fields left empty. Results will pop up in a new window. LIB's rule of thumb: BLOS grades A/B/C are "comfortable enough" for more experienced cyclists, as are A/B for a broader range of adults. If necessary, each group is usually willing to ride a road that is a half or full grade worse, but they will be uncomfortable doing so.

Some details on the BLOS input fields and their ranges are below. Further information and references on this and other measures

Through lanes per direction: (Default = 1)	1
Width of outside lane, to outside stripe, in ft: (Default = 12)	9
Paved shoulder, bike lane, OR marked parking area - outside lane stripe to pavement edge, in ft: (Def=0)	10
Bi-directional Traffic Volume in ADT: (Default = 4000)	983
Posted speed limit in mph: (Default = 30)	25
Percentage of heavy vehicles: (Default = 2)	2
FHWA's pavement condition rating: (5 = Best, 1 = Worst; Default = 4)	4
Percentage of road segment with occupied on-street parking: (Default = 0)	0

Calculate Reset

BLOS Calculator - Google Chrome

about:blank

Bicycle Level of Service for this road segment

Lanes per direction:	1
Outside lane width:	9 ft
Paved shoulder/bikelane width:	10 ft
Bidirectional ADT traffic volume:	983 (veh/day)
Posted speed limit:	25 mph
Heavy vehicle percentage:	2%
FHWA's pavement condition rating:	4
% of segment with occupied on-street parking:	0%

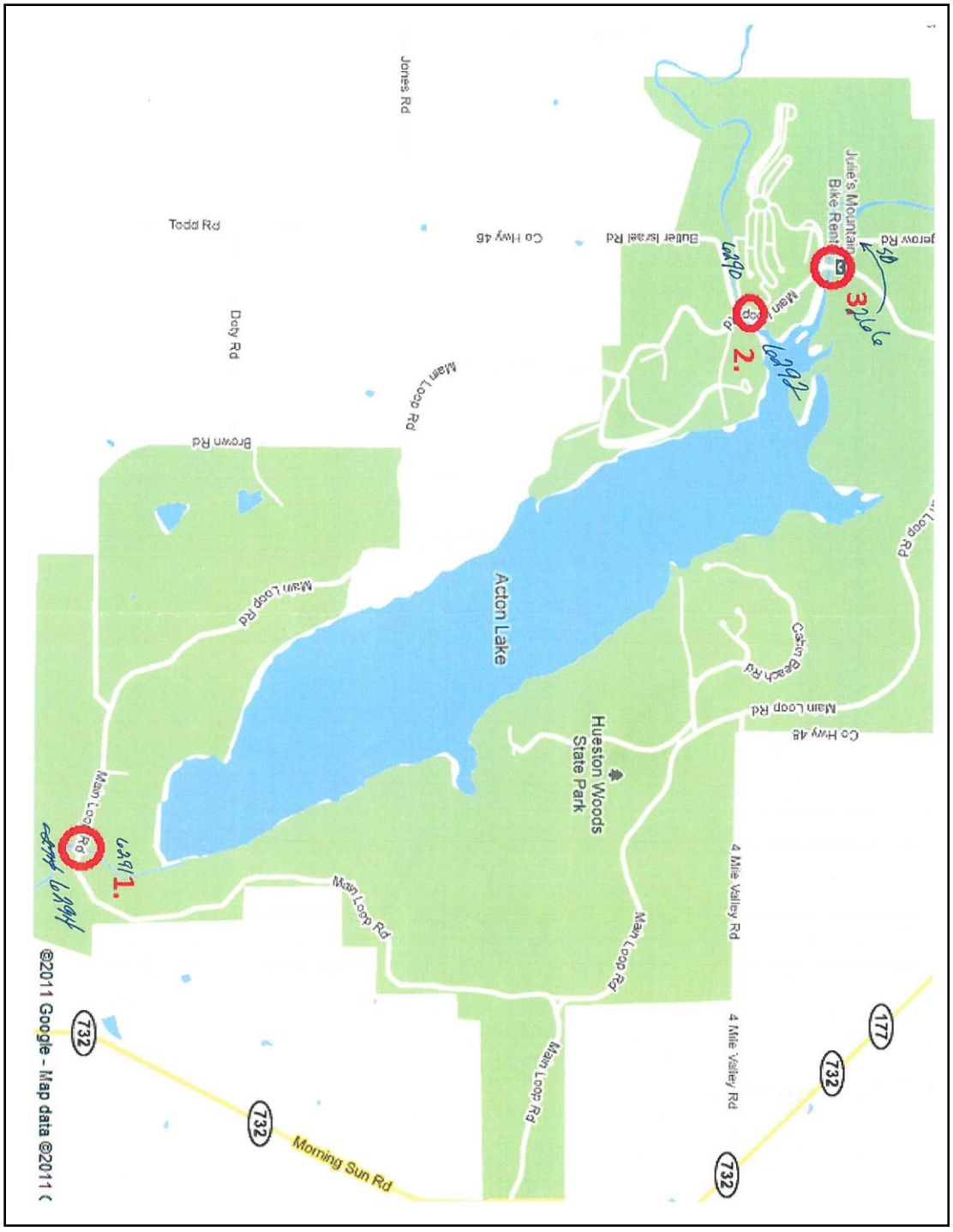
	Score	Level-of-service	Compatibility Level
BLOS:	-0.96	A (below 1.50)	Extremely High

Pavement Condition Ratings:

RATING	PAVEMENT CONDITION
5.0 (Very Good)	Only new or nearly new pavements are likely to be smooth enough and free of cracks and patches to qualify for this category.
4.0 (Good)	Pavement, although not as smooth as described above, gives a first class ride and exhibits signs of surface deterioration
3.0 (Fair)	Riding qualities are noticeably inferior to those above; may be barely tolerable for high-speed traffic. Defects may include rutting, map cracking, and extensive patching.
2.0 (Poor)	Pavements have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement has distress over 50 percent or more of the surface. Rigid pavement distress includes joint spalling, patching, etc.
1.0 (Very Poor)	Pavements that are in an extremely deteriorated condition. Distress occurs over 75 percent or more of the surface.

APPENDIX R. TRAFFIC COUNT DATA

Provided by Jay Hamilton, Traffic Planning Engineer, District 8, ODOT



Date/Time/Volume/Average Speed/Temperature Report

HI-Star ID: 266	Begin: 08/19/2011 06:00 PM	End: 08/21/2011 06:00 PM
Street:	Lane:	Hours: 48.00
State: OH	Oper: bv	Period: 60
City: Hueston Woods 3	Posted: ~~NB~~ SB	Raw Count: 1741
County: Butler	AADT Factor: 1	AADT Count: 871

Fri → Sat

Date & Time Range	Count	Avg Speed	Temp	Wet/Dry
08/19/2011 [06:00 PM-07:00 PM]	79	000 Mph	95 F	Dry
08/19/2011 [07:00 PM-08:00 PM]	50	000 Mph	91 F	Dry
08/19/2011 [08:00 PM-09:00 PM]	35	000 Mph	85 F	Dry
08/19/2011 [09:00 PM-10:00 PM]	24	000 Mph	83 F	Dry
08/19/2011 [10:00 PM-11:00 PM]	12	000 Mph	82 F	Dry
08/19/2011 [11:00 PM-12:00 AM]	9	000 Mph	80 F	Dry
08/20/2011 [12:00 AM-01:00 AM]	6	000 Mph	78 F	Dry
08/20/2011 [01:00 AM-02:00 AM]	4	000 Mph	76 F	Dry
08/20/2011 [02:00 AM-03:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [03:00 AM-04:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [04:00 AM-05:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [05:00 AM-06:00 AM]	4	000 Mph	76 F	Dry
08/20/2011 [06:00 AM-07:00 AM]	18	000 Mph	76 F	Dry
08/20/2011 [07:00 AM-08:00 AM]	60	000 Mph	76 F	Dry
08/20/2011 [08:00 AM-09:00 AM]	29	000 Mph	76 F	Dry
08/20/2011 [09:00 AM-10:00 AM]	44	000 Mph	83 F	Dry
08/20/2011 [10:00 AM-11:00 AM]	49	000 Mph	89 F	Dry
08/20/2011 [11:00 AM-12:00 PM]	67	000 Mph	101 F	Dry
08/20/2011 [12:00 PM-01:00 PM]	68	000 Mph	109 F	Dry
08/20/2011 [01:00 PM-02:00 PM]	99	000 Mph	111 F	Dry
08/20/2011 [02:00 PM-03:00 PM]	94	000 Mph	119 F	Dry
08/20/2011 [03:00 PM-04:00 PM]	79	000 Mph	113 F	Dry
08/20/2011 [04:00 PM-05:00 PM]	84	000 Mph	107 F	Dry
08/20/2011 [05:00 PM-06:00 PM]	81	000 Mph	103 F	Dry
08/20/2011 [06:00 PM-07:00 PM]	75	000 Mph	97 F	Dry
08/20/2011 [07:00 PM-08:00 PM]	49	000 Mph	93 F	Dry
08/20/2011 [08:00 PM-09:00 PM]	33	000 Mph	89 F	Dry
08/20/2011 [09:00 PM-10:00 PM]	16	000 Mph	87 F	Dry
08/20/2011 [10:00 PM-11:00 PM]	9	000 Mph	85 F	Dry
08/20/2011 [11:00 PM-12:00 AM]	5	000 Mph	83 F	Dry
08/21/2011 [12:00 AM-01:00 AM]	6	000 Mph	83 F	Dry
08/21/2011 [01:00 AM-02:00 AM]	5	000 Mph	83 F	Dry
08/21/2011 [02:00 AM-03:00 AM]	0	000 Mph	82 F	Dry
08/21/2011 [03:00 AM-04:00 AM]	1	000 Mph	80 F	Dry
08/21/2011 [04:00 AM-05:00 AM]	1	000 Mph	78 F	Dry
08/21/2011 [05:00 AM-06:00 AM]	4	000 Mph	78 F	Dry
08/21/2011 [06:00 AM-07:00 AM]	3	000 Mph	78 F	Dry
08/21/2011 [07:00 AM-08:00 AM]	18	000 Mph	78 F	Dry
08/21/2011 [08:00 AM-09:00 AM]	24	000 Mph	80 F	Dry
08/21/2011 [09:00 AM-10:00 AM]	21	000 Mph	83 F	Dry
08/21/2011 [10:00 AM-11:00 AM]	39	000 Mph	89 F	Dry
08/21/2011 [11:00 AM-12:00 PM]	83	000 Mph	101 F	Dry
08/21/2011 [12:00 PM-01:00 PM]	65	000 Mph	111 F	Dry
08/21/2011 [01:00 PM-02:00 PM]	63	000 Mph	119 F	Dry
08/21/2011 [02:00 PM-03:00 PM]	65	000 Mph	119 F	Dry
08/21/2011 [03:00 PM-04:00 PM]	65	000 Mph	111 F	Dry
08/21/2011 [04:00 PM-05:00 PM]	45	000 Mph	97 F	Dry
08/21/2011 [05:00 PM-06:00 PM]	51	000 Mph	97 F	Dry

Sat → Sun

08/22/2011 Page:

Date/Time/Volume/Average Speed/Temperature Report

HI-Star ID: 6290	Begin: 08/19/2011 06:00 PM	End: 08/21/2011 06:00 PM
Street: Hueston Woods 2	Lane: SB	Hours: 48.00
State: Oh	Oper: bv	Period: 60
City:	Posted:	Raw Count: 1966
County: Butler	AADT Factor: 1	AADT Count: 983

Date & Time Range	Count	Avg Speed	Temp	Wet/Dry
08/19/2011 [06:00 PM-07:00 PM]	55	025 Mph	85 F	Dry
08/19/2011 [07:00 PM-08:00 PM]	33	028 Mph	83 F	Dry
08/19/2011 [08:00 PM-09:00 PM]	30	024 Mph	80 F	Dry
08/19/2011 [09:00 PM-10:00 PM]	23	026 Mph	78 F	Dry
08/19/2011 [10:00 PM-11:00 PM]	12	024 Mph	78 F	Dry
08/19/2011 [11:00 PM-12:00 AM]	15	024 Mph	76 F	Dry
08/20/2011 [12:00 AM-01:00 AM]	6	029 Mph	76 F	Dry
08/20/2011 [01:00 AM-02:00 AM]	3	028 Mph	76 F	Dry
08/20/2011 [02:00 AM-03:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [03:00 AM-04:00 AM]	0	000 Mph	74 F	Dry
08/20/2011 [04:00 AM-05:00 AM]	2	028 Mph	74 F	Dry
08/20/2011 [05:00 AM-06:00 AM]	3	025 Mph	72 F	Dry
08/20/2011 [06:00 AM-07:00 AM]	19	026 Mph	72 F	Dry
08/20/2011 [07:00 AM-08:00 AM]	63	028 Mph	72 F	Dry
08/20/2011 [08:00 AM-09:00 AM]	38	026 Mph	74 F	Dry
08/20/2011 [09:00 AM-10:00 AM]	69	026 Mph	78 F	Dry
08/20/2011 [10:00 AM-11:00 AM]	65	025 Mph	82 F	Dry
08/20/2011 [11:00 AM-12:00 PM]	88	027 Mph	89 F	Dry
08/20/2011 [12:00 PM-01:00 PM]	86	026 Mph	99 F	Dry
08/20/2011 [01:00 PM-02:00 PM]	116	026 Mph	99 F	Dry
08/20/2011 [02:00 PM-03:00 PM]	102	026 Mph	97 F	Dry
08/20/2011 [03:00 PM-04:00 PM]	106	027 Mph	95 F	Dry
08/20/2011 [04:00 PM-05:00 PM]	73	026 Mph	95 F	Dry
08/20/2011 [05:00 PM-06:00 PM]	81	025 Mph	91 F	Dry
08/20/2011 [06:00 PM-07:00 PM]	74	027 Mph	89 F	Dry
08/20/2011 [07:00 PM-08:00 PM]	48	026 Mph	85 F	Dry
08/20/2011 [08:00 PM-09:00 PM]	33	025 Mph	83 F	Dry
08/20/2011 [09:00 PM-10:00 PM]	23	024 Mph	82 F	Dry
08/20/2011 [10:00 PM-11:00 PM]	15	024 Mph	80 F	Dry
08/20/2011 [11:00 PM-12:00 AM]	8	023 Mph	80 F	Dry
08/21/2011 [12:00 AM-01:00 AM]	7	026 Mph	78 F	Dry
08/21/2011 [01:00 AM-02:00 AM]	5	021 Mph	78 F	Dry
08/21/2011 [02:00 AM-03:00 AM]	1	010 Mph	78 F	Dry
08/21/2011 [03:00 AM-04:00 AM]	0	000 Mph	76 F	Dry
08/21/2011 [04:00 AM-05:00 AM]	1	030 Mph	76 F	Dry
08/21/2011 [05:00 AM-06:00 AM]	3	023 Mph	76 F	Dry
08/21/2011 [06:00 AM-07:00 AM]	5	026 Mph	76 F	Dry
08/21/2011 [07:00 AM-08:00 AM]	24	025 Mph	76 F	Dry
08/21/2011 [08:00 AM-09:00 AM]	29	028 Mph	76 F	Dry
08/21/2011 [09:00 AM-10:00 AM]	36	026 Mph	80 F	Dry
08/21/2011 [10:00 AM-11:00 AM]	60	026 Mph	83 F	Dry
08/21/2011 [11:00 AM-12:00 PM]	115	026 Mph	89 F	Dry
08/21/2011 [12:00 PM-01:00 PM]	72	027 Mph	107 F	Dry
08/21/2011 [01:00 PM-02:00 PM]	72	027 Mph	113 F	Dry
08/21/2011 [02:00 PM-03:00 PM]	79	027 Mph	101 F	Dry
08/21/2011 [03:00 PM-04:00 PM]	72	026 Mph	97 F	Dry
08/21/2011 [04:00 PM-05:00 PM]	47	027 Mph	89 F	Dry
08/21/2011 [05:00 PM-06:00 PM]	49	028 Mph	89 F	Dry

Fri → Sat

Sat → Sun

08/22/2011 Page:

Date/Time/Volume/Average Speed/Temperature Report

HI-Star ID: 6294	Begin: 08/19/2011 06:00 PM	End: 08/21/2011 06:00 PM
Street: Hueston Woods 1	Lane: EB	Hours: 48.00
State: Oh	Oper: bv	Period: 60
City:	Posted:	Raw Count: 354
County: Butler	AADT Factor: 1	AADT Count: 177

Date & Time Range	Count	Avg Speed	Temp	Wet/Dry
08/19/2011 [06:00 PM-07:00 PM]	7	029 Mph	97 F	Dry
08/19/2011 [07:00 PM-08:00 PM]	11	028 Mph	91 F	Dry
08/19/2011 [08:00 PM-09:00 PM]	8	032 Mph	85 F	Dry
08/19/2011 [09:00 PM-10:00 PM]	4	029 Mph	83 F	Dry
08/19/2011 [10:00 PM-11:00 PM]	3	025 Mph	82 F	Dry
08/19/2011 [11:00 PM-12:00 AM]	3	035 Mph	80 F	Dry
08/20/2011 [12:00 AM-01:00 AM]	1	025 Mph	78 F	Dry
08/20/2011 [01:00 AM-02:00 AM]	1	030 Mph	76 F	Dry
08/20/2011 [02:00 AM-03:00 AM]	2	035 Mph	76 F	Dry
08/20/2011 [03:00 AM-04:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [04:00 AM-05:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [05:00 AM-06:00 AM]	0	000 Mph	74 F	Dry
08/20/2011 [06:00 AM-07:00 AM]	0	000 Mph	74 F	Dry
08/20/2011 [07:00 AM-08:00 AM]	2	038 Mph	76 F	Dry
08/20/2011 [08:00 AM-09:00 AM]	7	032 Mph	85 F	Dry
08/20/2011 [09:00 AM-10:00 AM]	10	028 Mph	97 F	Dry
08/20/2011 [10:00 AM-11:00 AM]	10	034 Mph	105 F	Dry
08/20/2011 [11:00 AM-12:00 PM]	11	028 Mph	117 F	Dry
08/20/2011 [12:00 PM-01:00 PM]	9	024 Mph	121 F	Dry
08/20/2011 [01:00 PM-02:00 PM]	18	025 Mph	119 F	Dry
08/20/2011 [02:00 PM-03:00 PM]	14	032 Mph	126 F	Dry
08/20/2011 [03:00 PM-04:00 PM]	22	033 Mph	121 F	Dry
08/20/2011 [04:00 PM-05:00 PM]	17	027 Mph	113 F	Dry
08/20/2011 [05:00 PM-06:00 PM]	26	029 Mph	111 F	Dry
08/20/2011 [06:00 PM-07:00 PM]	20	033 Mph	99 F	Dry
08/20/2011 [07:00 PM-08:00 PM]	13	030 Mph	95 F	Dry
08/20/2011 [08:00 PM-09:00 PM]	12	030 Mph	89 F	Dry
08/20/2011 [09:00 PM-10:00 PM]	3	038 Mph	87 F	Dry
08/20/2011 [10:00 PM-11:00 PM]	5	032 Mph	85 F	Dry
08/20/2011 [11:00 PM-12:00 AM]	1	025 Mph	83 F	Dry
08/21/2011 [12:00 AM-01:00 AM]	0	000 Mph	83 F	Dry
08/21/2011 [01:00 AM-02:00 AM]	4	032 Mph	82 F	Dry
08/21/2011 [02:00 AM-03:00 AM]	1	030 Mph	80 F	Dry
08/21/2011 [03:00 AM-04:00 AM]	0	000 Mph	78 F	Dry
08/21/2011 [04:00 AM-05:00 AM]	0	000 Mph	78 F	Dry
08/21/2011 [05:00 AM-06:00 AM]	0	000 Mph	78 F	Dry
08/21/2011 [06:00 AM-07:00 AM]	1	030 Mph	78 F	Dry
08/21/2011 [07:00 AM-08:00 AM]	0	000 Mph	78 F	Dry
08/21/2011 [08:00 AM-09:00 AM]	2	022 Mph	85 F	Dry
08/21/2011 [09:00 AM-10:00 AM]	1	030 Mph	99 F	Dry
08/21/2011 [10:00 AM-11:00 AM]	11	031 Mph	103 F	Dry
08/21/2011 [11:00 AM-12:00 PM]	9	026 Mph	115 F	Dry
08/21/2011 [12:00 PM-01:00 PM]	9	027 Mph	109 F	Dry
08/21/2011 [01:00 PM-02:00 PM]	12	028 Mph	117 F	Dry
08/21/2011 [02:00 PM-03:00 PM]	17	029 Mph	125 F	Dry
08/21/2011 [03:00 PM-04:00 PM]	15	030 Mph	119 F	Dry
08/21/2011 [04:00 PM-05:00 PM]	20	027 Mph	97 F	Dry
08/21/2011 [05:00 PM-06:00 PM]	12	024 Mph	107 F	Dry

Fri → Sat

Sat → Sun

08/22/2011 Page:

Date/Time/Volume/Average Speed/Temperature Report

HI-Star ID: 6291	Begin: 08/19/2011 06:00 PM	End: 08/21/2011 06:00 PM
Street: Hueston Woods 1	Lane: WB	Hours: 48.00
State: Oh	Oper: bv	Period: 60
City:	Posted:	Raw Count: 269
County: Butler	AADT Factor: 1	AADT Count: 135

Date & Time Range	Count	Avg Speed	Temp	Wet/Dry
08/19/2011 [06:00 PM-07:00 PM]	5	031 Mph	107 F	Dry
08/19/2011 [07:00 PM-08:00 PM]	4	026 Mph	97 F	Dry
08/19/2011 [08:00 PM-09:00 PM]	6	029 Mph	91 F	Dry
08/19/2011 [09:00 PM-10:00 PM]	3	030 Mph	87 F	Dry
08/19/2011 [10:00 PM-11:00 PM]	0	000 Mph	85 F	Dry
08/19/2011 [11:00 PM-12:00 AM]	0	000 Mph	83 F	Dry
08/20/2011 [12:00 AM-01:00 AM]	1	030 Mph	82 F	Dry
08/20/2011 [01:00 AM-02:00 AM]	1	030 Mph	80 F	Dry
08/20/2011 [02:00 AM-03:00 AM]	1	030 Mph	78 F	Dry
08/20/2011 [03:00 AM-04:00 AM]	0	000 Mph	78 F	Dry
08/20/2011 [04:00 AM-05:00 AM]	1	025 Mph	76 F	Dry
08/20/2011 [05:00 AM-06:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [06:00 AM-07:00 AM]	0	000 Mph	76 F	Dry
08/20/2011 [07:00 AM-08:00 AM]	7	034 Mph	78 F	Dry
08/20/2011 [08:00 AM-09:00 AM]	9	036 Mph	85 F	Dry
08/20/2011 [09:00 AM-10:00 AM]	8	034 Mph	97 F	Dry
08/20/2011 [10:00 AM-11:00 AM]	6	026 Mph	103 F	Dry
08/20/2011 [11:00 AM-12:00 PM]	8	028 Mph	115 F	Dry
08/20/2011 [12:00 PM-01:00 PM]	10	026 Mph	119 F	Dry
08/20/2011 [01:00 PM-02:00 PM]	15	029 Mph	119 F	Dry
08/20/2011 [02:00 PM-03:00 PM]	15	026 Mph	125 F	Dry
08/20/2011 [03:00 PM-04:00 PM]	12	029 Mph	119 F	Dry
08/20/2011 [04:00 PM-05:00 PM]	7	027 Mph	113 F	Dry
08/20/2011 [05:00 PM-06:00 PM]	10	030 Mph	113 F	Dry
08/20/2011 [06:00 PM-07:00 PM]	4	022 Mph	101 F	Dry
08/20/2011 [07:00 PM-08:00 PM]	8	026 Mph	97 F	Dry
08/20/2011 [08:00 PM-09:00 PM]	2	010 Mph	91 F	Dry
08/20/2011 [09:00 PM-10:00 PM]	3	035 Mph	89 F	Dry
08/20/2011 [10:00 PM-11:00 PM]	2	025 Mph	87 F	Dry
08/20/2011 [11:00 PM-12:00 AM]	0	000 Mph	85 F	Dry
08/21/2011 [12:00 AM-01:00 AM]	1	040 Mph	85 F	Dry
08/21/2011 [01:00 AM-02:00 AM]	1	035 Mph	83 F	Dry
08/21/2011 [02:00 AM-03:00 AM]	1	040 Mph	82 F	Dry
08/21/2011 [03:00 AM-04:00 AM]	0	000 Mph	80 F	Dry
08/21/2011 [04:00 AM-05:00 AM]	0	000 Mph	80 F	Dry
08/21/2011 [05:00 AM-06:00 AM]	0	000 Mph	78 F	Dry
08/21/2011 [06:00 AM-07:00 AM]	1	025 Mph	80 F	Dry
08/21/2011 [07:00 AM-08:00 AM]	3	033 Mph	80 F	Dry
08/21/2011 [08:00 AM-09:00 AM]	9	033 Mph	87 F	Dry
08/21/2011 [09:00 AM-10:00 AM]	3	035 Mph	99 F	Dry
08/21/2011 [10:00 AM-11:00 AM]	8	032 Mph	103 F	Dry
08/21/2011 [11:00 AM-12:00 PM]	9	027 Mph	113 F	Dry
08/21/2011 [12:00 PM-01:00 PM]	4	026 Mph	109 F	Dry
08/21/2011 [01:00 PM-02:00 PM]	24	028 Mph	115 F	Dry
08/21/2011 [02:00 PM-03:00 PM]	16	031 Mph	125 F	Dry
08/21/2011 [03:00 PM-04:00 PM]	12	025 Mph	119 F	Dry
08/21/2011 [04:00 PM-05:00 PM]	20	026 Mph	101 F	Dry
08/21/2011 [05:00 PM-06:00 PM]	9	027 Mph	109 F	Dry

Fri → Sat

Sat → Sun

08/22/2011 Page:

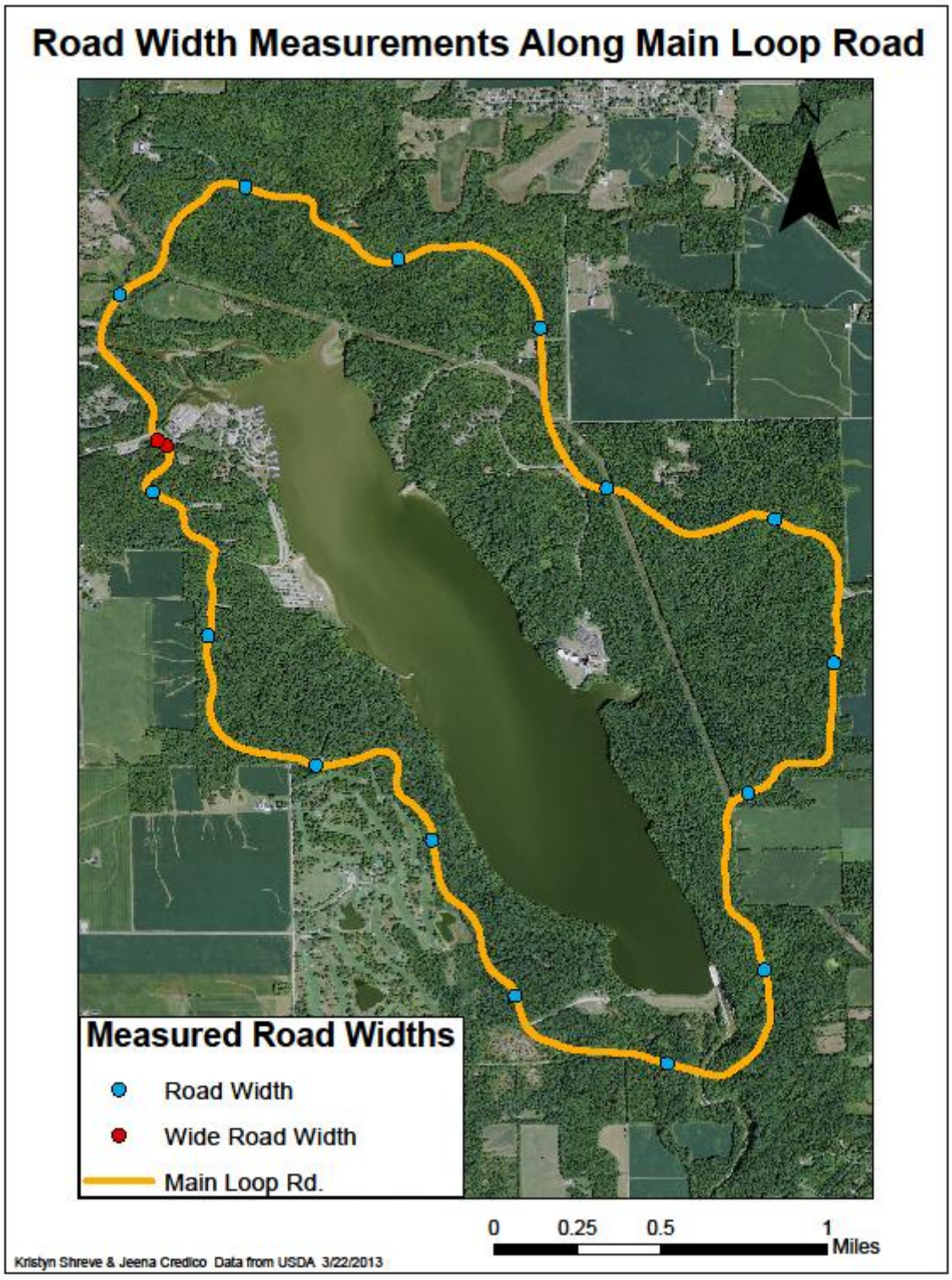
APPENDIX S. ROAD AND SHOULDER WIDTH MEASUREMENTS

ROAD WIDTH MEASUREMENTS

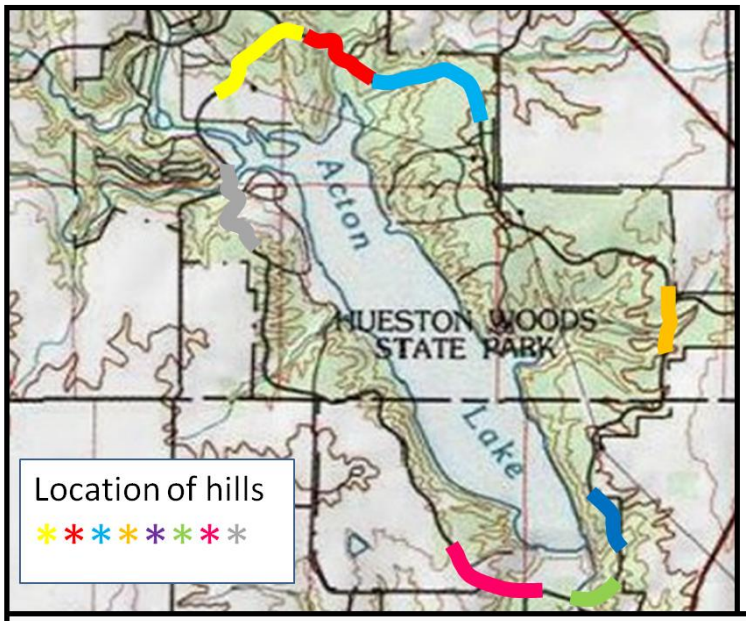
Measurement	Inside Feet	Inside Inches	Outside Feet	Outside Inches	Total Feet	Total Inches	Total
1	11	8	10	7	21	15	22'3"
2	11	5	10	1	21	6	21'6"
3	14	11	21	5	35	16	36'4"
4	12	2	28	11	40	13	41'1"
5	11	2	11	1	22	3	22'3"
6	10	8	11	6	21	14	22'2"
7	10	9	11	11	21	18	22'6"
8	11	4	10	8	21	12	22'
9	10	6	9	11	19	17	20'5"
10	10	5	10	2	20	7	20'7"
11	11	8	11	2	22	10	22"10"
12	11	1	10	11	21	12	22'
13	11	0	11	7	22	7	22'7"
14	10	11	11	4	21	15	22'3"
15	11	1	11	2	22	3	22'3"
16	10	11	10	7	20	18	21'6"
17	11	0	11	4	22	4	22'4"
Average 11.965 feet per lane							

SHOULDER WIDTH MEASUREMENTS

Measurement	Inside Feet	Inside Inches	Outside Feet	Outside Inches	Total Feet	Total Inches	Total
1	0	6.5	0	4	0	10.5	10.5''
2	0	9.5	0	2	0	11.5	11.5''
3	1	8	1	5	2	10	2'10''
4	2	1	0	8	2	9	2'9''
5	0	5	0	5	0	10	10''
6	0	6	0	3	0	9	9''
7	0	1	0	3	0	4	4''
8	0	6	0	6	0	12	1'
9	0	7	0	5	0	12	1'
10	0	11.5	0	9	0	20.5	1'8.5''
11	0	5	0	4	0	9	9''
12	0	3.5	0	7.5	0	11	11''
13	0	3	0	7	0	10	10''
14	0	6	0	5	0	11	11''
15	0	9	0	5	0	14	1'2''
16	0	4.5	0	8	0	12.5'	1'0.5''
17	0	3.5	0	4	0	7.5	7.5''
Average 6.44 inches per shoulder							


Road Width Measurements Along Main Loop Road
N
Measured Road Widths
Road Width
Wide Road Width
Main Loop Rd.
0
0.25
0.5
1
Miles
Kristyn Shreve & Jeena Credico Data from USDA 3/22/2013

Hill Gradients Around Main Loop Rd



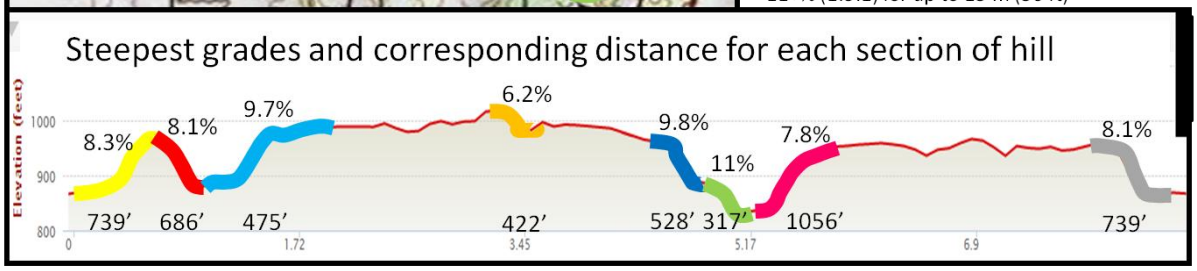
AASHTO 16.2.7.2 - Suggests avoiding the following gradients and their associated distances. The guidelines are progressively applied, as each prior guideline may be found to be unavoidable.

Running Gradient:

1:20 (5%) any length;
1:12 (8.33%) for up to 200 feet;
1:10 (10%) for up to 30 feet;
1:8 (12.5%) for up to 10 feet;
No more than 30% of the total trail length shall exceed 1:12

Bicycling Gradient:

< 5% (< 1:20) any length
5-6% (1:20-16.7) for up to 240 m (800 ft)
7% (1:14.3) for up to 120 m (400 ft)
8% (1:12.5) for up to 90 m (300 ft)
9% (1:11.1) for up to 60 m (200 ft)
10% (1:10) for up to 30 m (100 ft)
11+% (1:9.1) for up to 15 m (50 ft)



Original Topography Map courtesy of USGS

Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

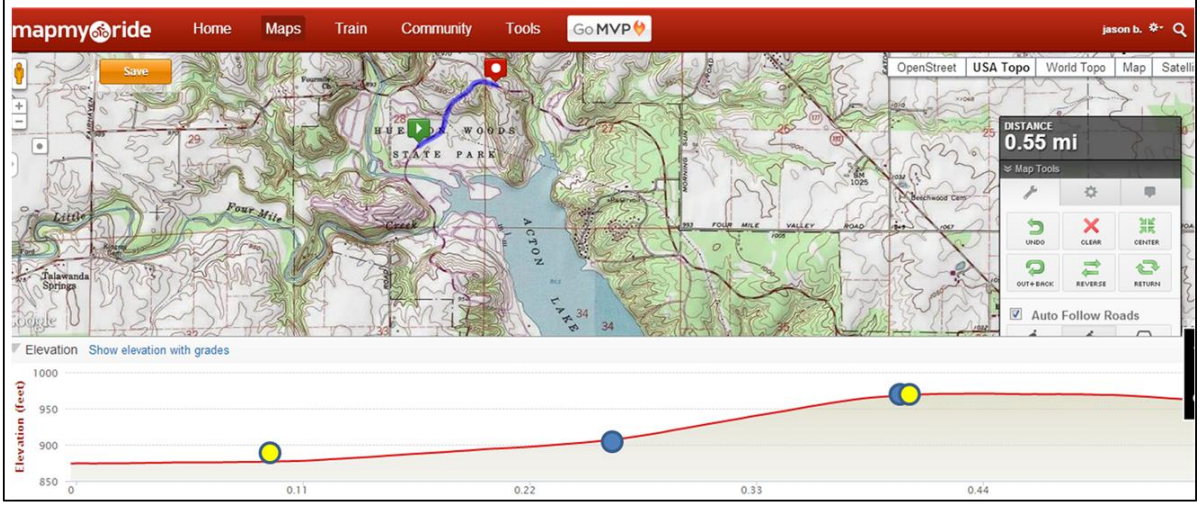
Hill 1 in Yellow on Gradient Map

Average hill gradient:

(970ft-876ft)/((.4mi-.09mi)*5280f/mi)= 5.6% over 1690 feet

Steepest hill gradient:

(970ft-909ft)/(.41mi-.27mi)*5280ft/mi)= 8.3% over 739 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

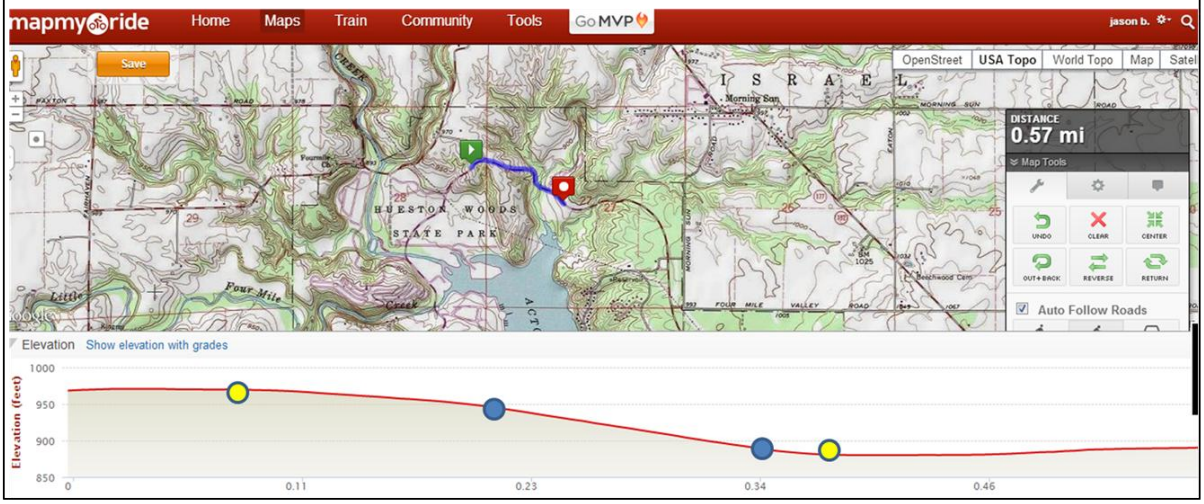
Hill 2 in Red on Gradient Map

Average hill gradient:

(970ft-880ft)/((.39mi-.08mi)*5280f/mi)= 5.5% over 1637 feet

Steepest hill gradient:

(943ft-887ft)/(.35mi-.22mi)*5280ft/mi)= 8.1% over 686 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

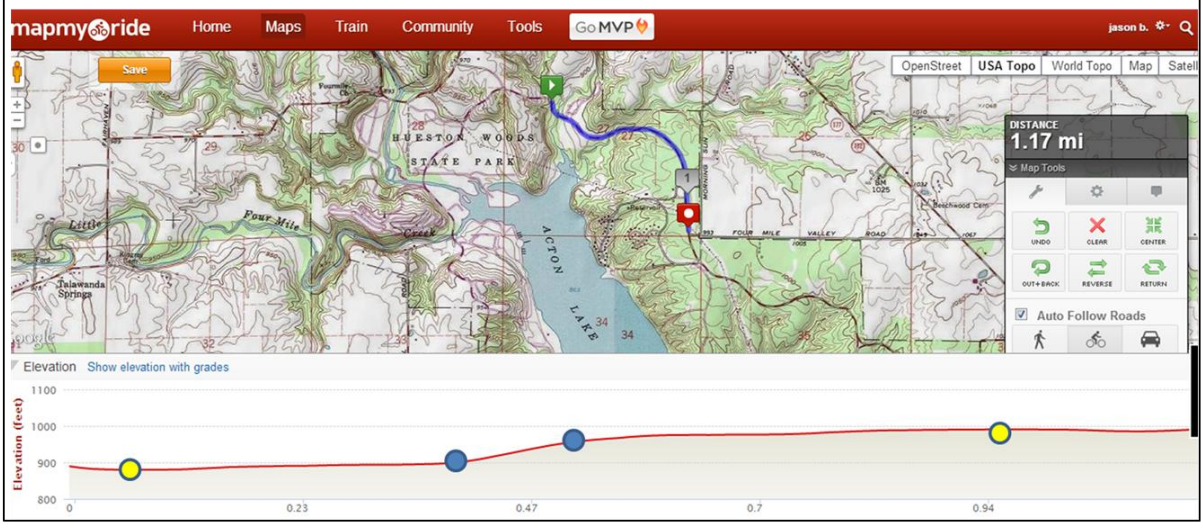
Hill 3 in Light Blue on Gradient Map

Average hill gradient:

(990ft-880ft)/((.9mi-.11mi)*5280f/mi)= 2.6% over 4171 feet

Steepest hill gradient:

(946ft-900ft)/(.49mi-.4mi)*5280ft/mi)= 9.7% over 475 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

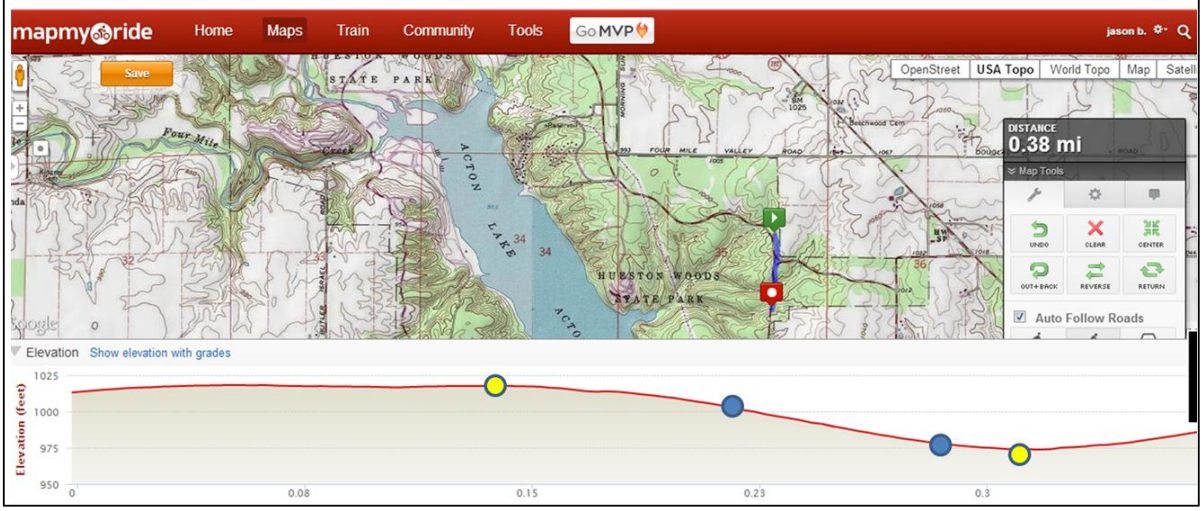
Hill 4 in Orange on Gradient Map

Average hill gradient:

(1017ft-974ft)/((.32mi-.15mi)*5280f/mi)= 4.8% over 898feet

Steepest hill gradient:

(1005ft-979ft)/(.29mi-.21mi)*5280ft/mi)= 6.2% over 422 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

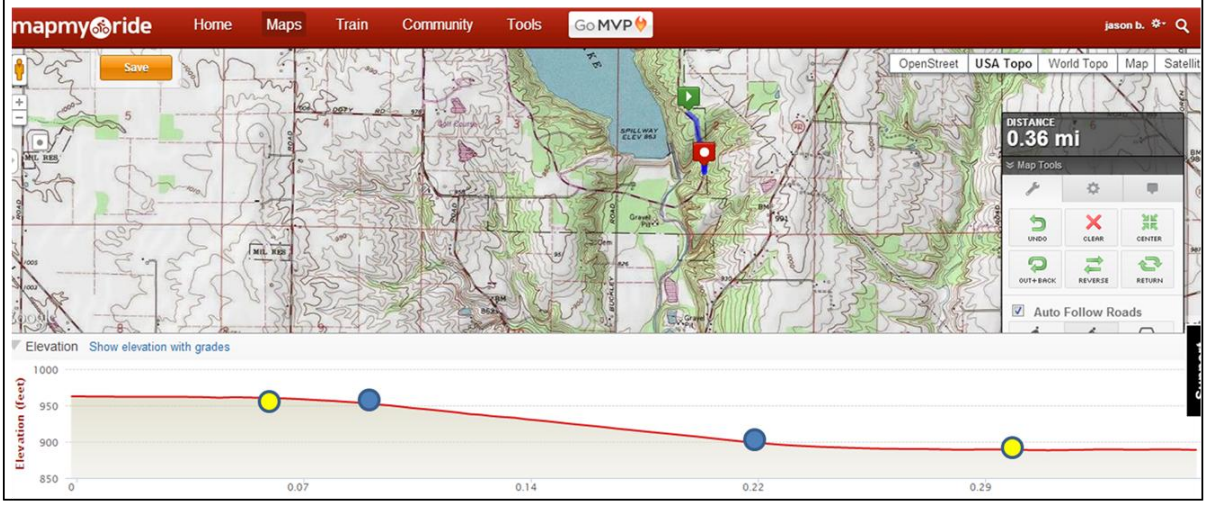
Hill 5 in Blue on Gradient Map

Average hill gradient:

(961ft-888ft)/((.3mi-.05mi)*5280f/mi)= 5.5% over 1320 feet

Steepest hill gradient:

(951ft-899ft)/(.2mi-.1mi)*5280ft/mi)= 9.8% over 528 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

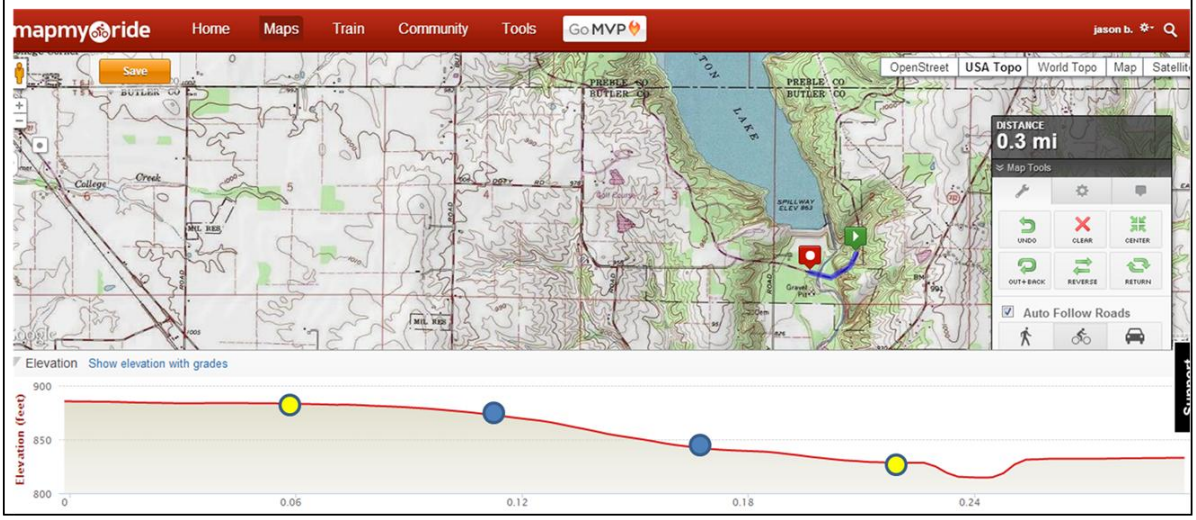
Hill 6 in Green on Gradient Map

Average hill gradient:

(883ft-828ft)/((.22mi-.06mi)*5280f/mi)= 6.5 % over 845 feet

Steepest hill gradient:

(875ft-840ft)/(.17mi-.11mi)*5280ft/mi)= 11.0% over 317 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

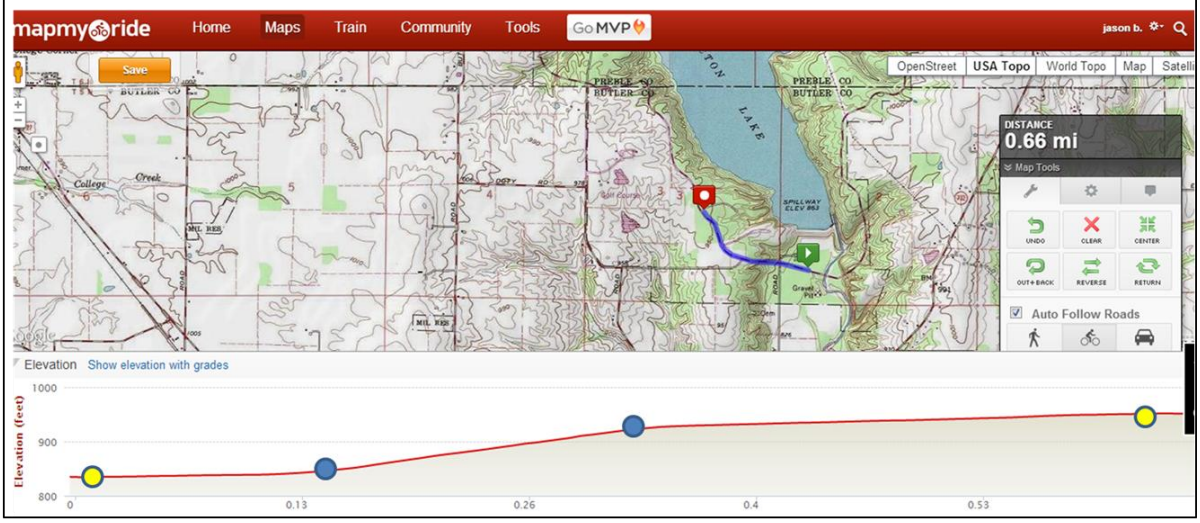
Hill 7 in Pink on Gradient Map

Average hill gradient:

(951ft-834ft)/((.62mi-.01mi)*5280f/mi)= 3.6 % over 3221 feet

Steepest hill gradient:

(925ft-843ft)/(.34mi-.14mi)*5280ft/mi)= 7.8% over 1056 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

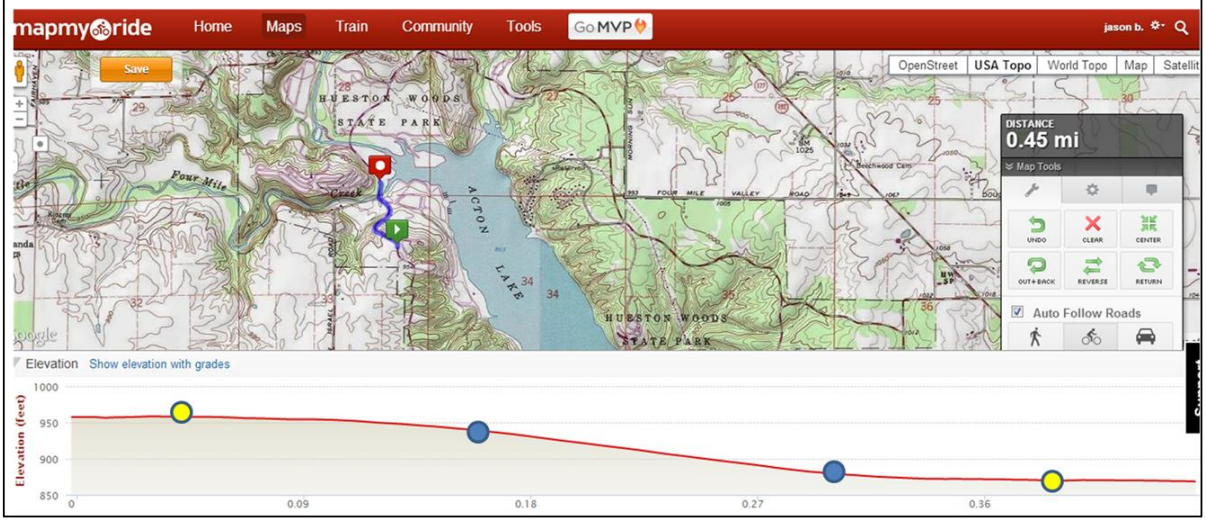
Hill 8 in Grey on Gradient Map

Average hill gradient:

(958ft-870ft)/((.62mi-.38mi)*5280f/mi)= 6.9% over 1267 feet

Steepest hill gradient:

(940ft-880ft)/(.3mi-.16mi)*5280ft/mi)= 8.1% over 739 feet



Original Elevation Map courtesy of Map My Ride
http://mapmyride.com/route/create

APPENDIX U. TYPES OF BIKEWAYS

(Association of State Highway 2012, 17-20)

Type of Bikeway	Best Use	Motor Vehicle Speed	Traffic Volume
Shared lanes	Minor Roads with low volumes, where bicyclists can share the road with no special provisions.	Speeds vary based on location (rural or urban).	Generally less than 1,000 vehicles per day.
Shared lanes (wide outside lanes)	Major roads where bike lanes are not selected due to space constraints or other limitations.	Variable. Use as the speed differential between bicyclist and motorists increases. Generally any road where the design speed is more than 25 mph.	Generally more than 3,000 vehicles per day.
Marked shared lanes	Space-constrained roads with narrow travel lanes, or road segments upon which bike lanes are not selected due to space constraints or other limitations.	Variable. Use where the speed limit is 35 mph or less.	Variable. Useful where there is a high turnover in on-street parking to prevent crashes with open car doors.
Paved shoulders	Rural highways that connect town centers and other major attractors.	Variable. Typical posted highway speeds (generally 40-55 mph).	Variable.
Bike lanes	Major roads that provide direct, convenient, quick access to major land uses. Also can be used on collector roads and busy urban streets with slower speeds.	Generally, any roads where the design speed is more than 25 mph.	Variable. Speed differential is generally a more important factor in the decision to provide bike lanes than traffic volumes.
Bicycle boulevards	Local roads with low volumes and speeds, offering an alternative to, but running parallel to, major roads. Still should offer convenient access to lane use destinations.	Use where the speed differential between motorists and bicyclists is typically 15 mph or less. Generally, posted limits of 25 mph or less.	Generally less than 3,000 vehicles per day.
Shared use path: independent right-of-way	Linear corridors in greenways, or along waterways, freeways, active or abandoned rail lines, utility rights-of-way, unused rights-of-way. May be a short connection, such as a connector between two cul-de-sacs, or a longer connection between cities.	N/A	N/A

APPENDIX V. POTENTIAL SHARED USE PATHS WITH INDEPENDENT RIGHT-OF-WAYS

Several shared use paths with independent right-of-ways were investigated to evaluate the potential for obstacle avoidance and increased or improved recreational opportunity.

The major obstacles that would warrant significant shared use paths with independent right-of-way alternatives were steep hills and culverts. These obstacles were not avoidable as they were present due to topographic features that tended to run from the park boundary all the way to Lake Acton and could not be circumvented. There were several areas however, that while not circumventing any of these obstacles could still be explored for use as additional bicycle or pedestrian paths aside from Main Loop Rd.

The areas selected for investigation appeared to be topographically suited for ease of travel and connectivity with popular park attractions. Three areas were initially designated for these potential shared use paths with independent right-of-way alternatives: the area north of the Lodge, the Marina, and Hedge Row Rd.

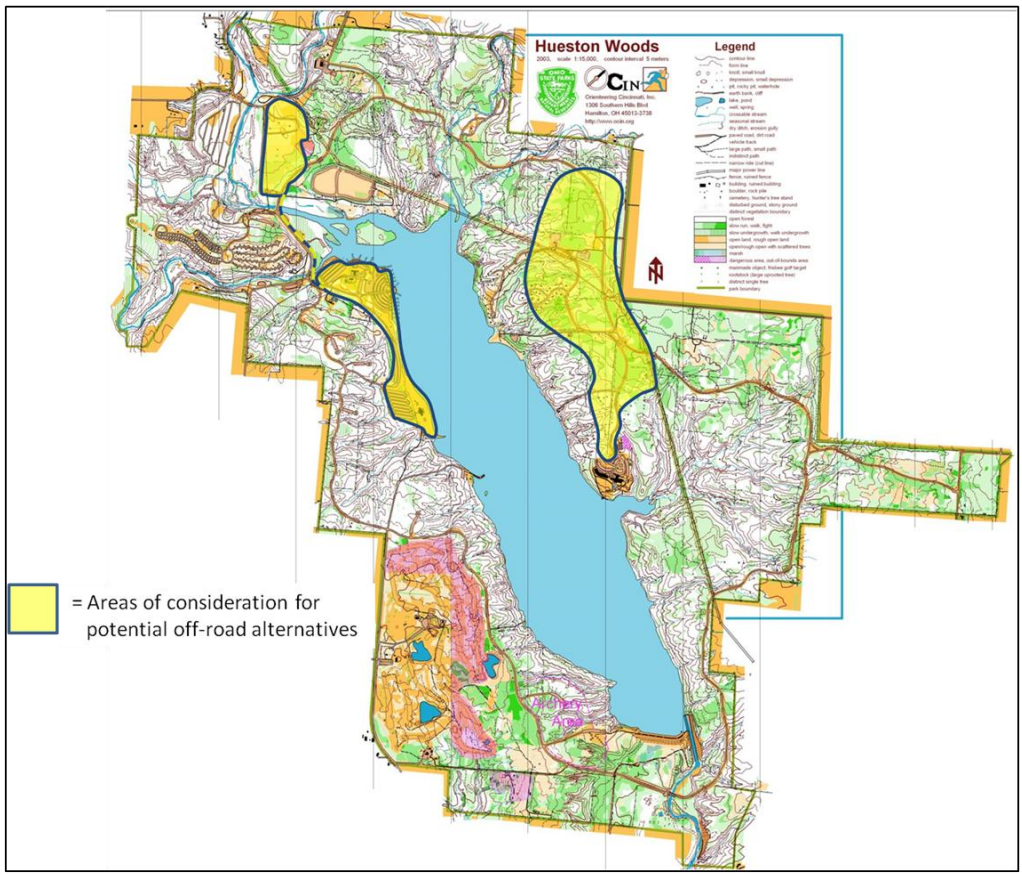
Upon further investigation the area north of the Lodge was dismissed as potential paths would encounter significant topographic difficulties and/or interfere significantly with other recreational features such as the designated horse trails or disc golf course.

The Marina was deemed potentially suitable and a potential GPS trail loop was recorded that attempted to avoid potential safety concerns such as road crossings while enhancing the usability. The benefits to such a potential trail are that it is a relatively flat riding area with a scenic view of the lake and provides short connections between popular attractions such as the park office, nature center, and nature preserve. The drawbacks of the potential trail are that it does not cover a significant distance (~1.7 mile loop, ~.8 mile straight line distance), it would include several road crossings and, more worrisome, a boat ramp area. The scenic view of the lake also include views of large parking lots, and it may not represent a significant safety improvement as the general area is already a 10 mph speed limit zone with little obstructed view and the expectation of people present.

Hedge Row Rd was also deemed potentially suitable. The area is scenic and flat and a good destination for recreational activities. The area is good for picnics and there are connections to the mountain bike trails. The drawbacks of such a potential trail are that it covers a very small distance (~1 mile loop, ~.3 mile straight line distance) and the area may already be a relatively safe pedestrian and cycling area with good visibility and a posted speed limit of 25mph.

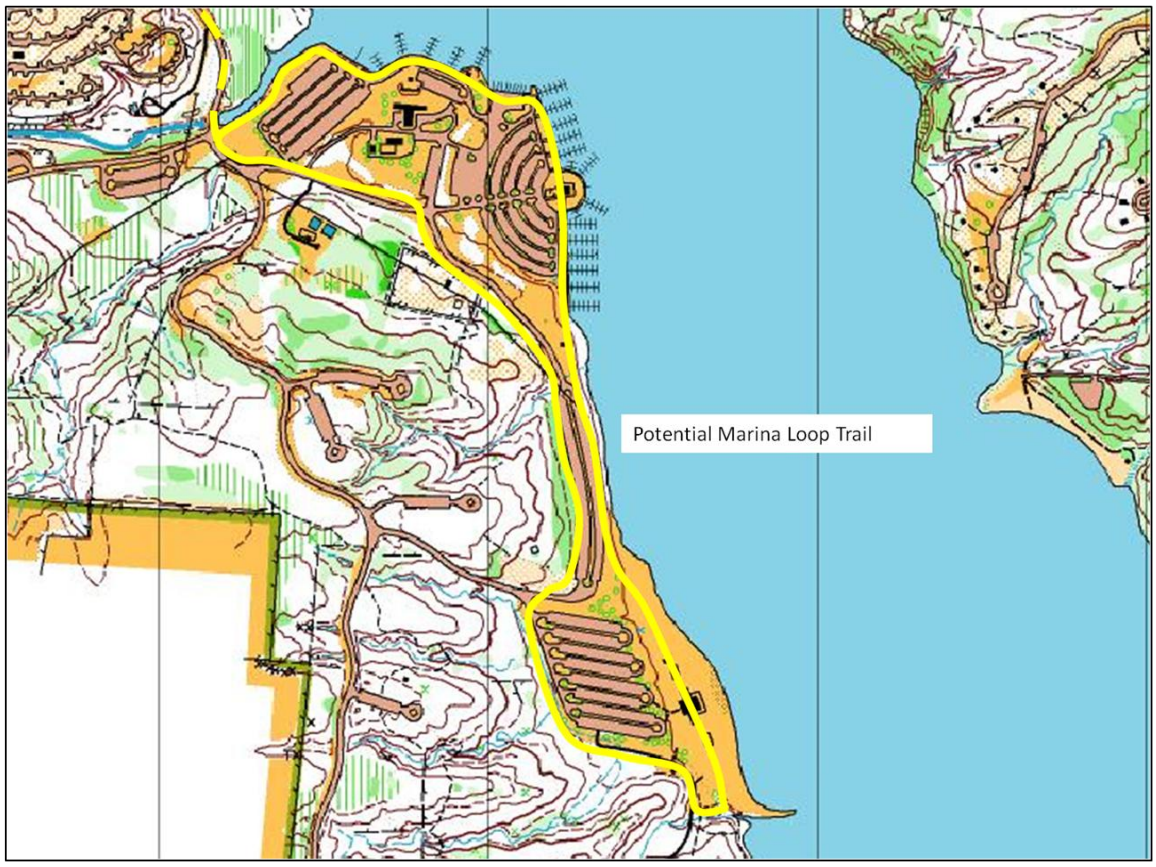
There is also the potential to connect a possible Marina trail and a Hedge Row trail, however, this would entail road travel at the points of two culverts that separate these areas. These areas might present safety concerns over the potential for bottlenecks.

Map of Potential Off Road Trails Areas



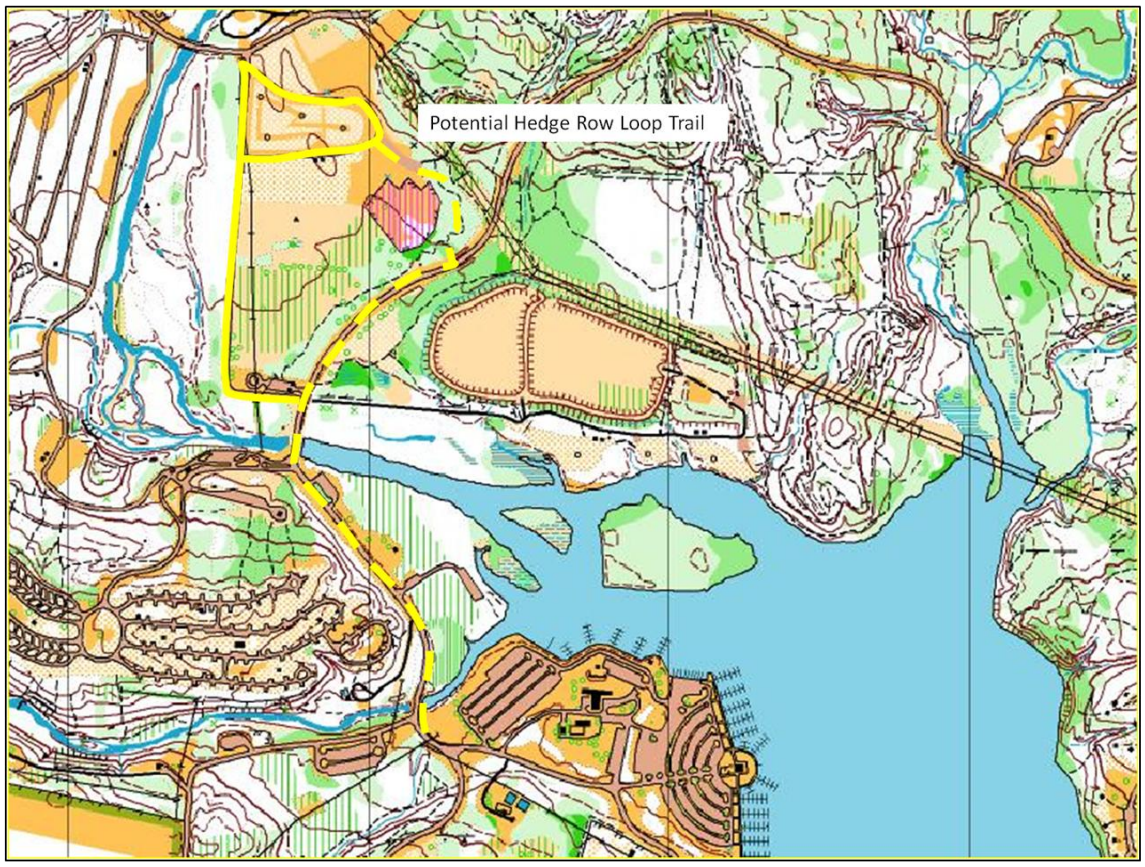
Original Map courtesy of Cincinnati Orienteering

Marina Area Potential Off Road Trail



Original Map courtesy of Cincinnati Orienteering

Hedge Row Area Potential Off Road Trail



Original Map courtesy of Cincinnati Orienteering

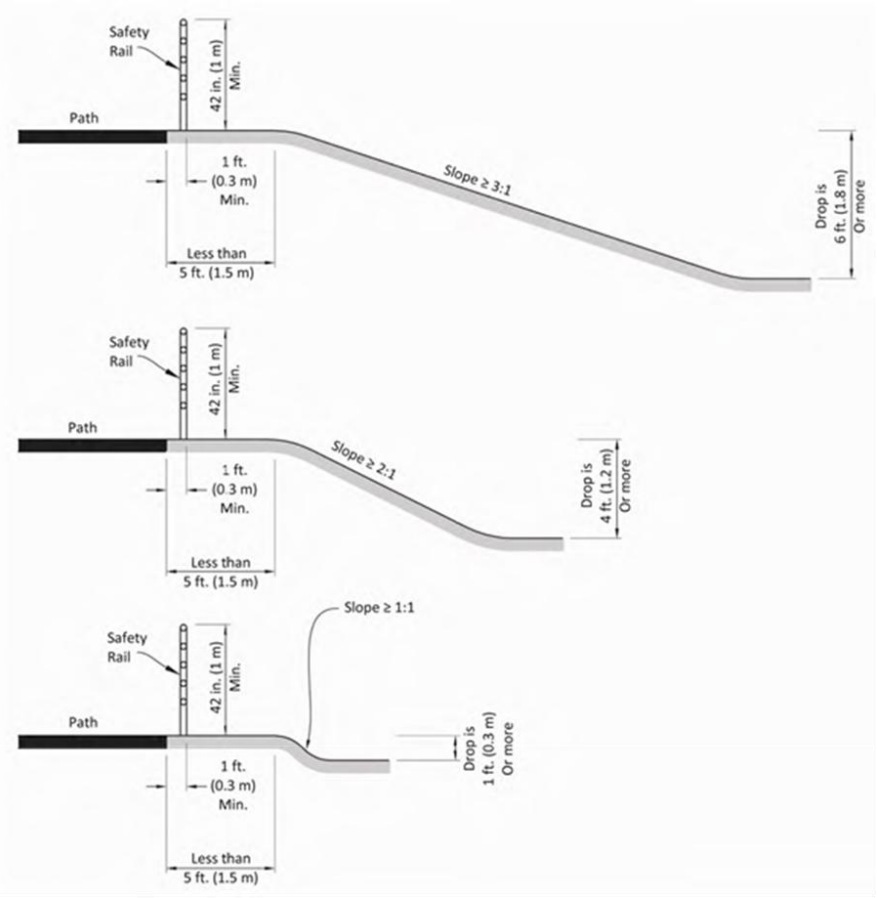
APPENDIX W. OHIO MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES SIGNAGE AND MARKINGS REGULATION

(Ohio Department of Transportation 2012)

Type of Bikeway	Signage Requirements	Marking Requirements
Maintain Shared Lanes	N/A	**N/A**
Marked Shared Lanes	"Bicycle signs shall be standard in shape, legend, and color."	**N/A**
	"All signs shall be retro reflectorized for use on bikeways, including shared-use paths and bicycle lane facilities."	
	"Where signs serve both bicyclists and other road users, vertical mounting height and lateral placement shall be as provided in Part 2."	
	"All object markers shall be retroreflective."	
	"On Type 3 object markers, the alternating black and retroreflective yellow stripes shall be sloped down at an angle of 45 degrees toward the side on which traffic is to pass the obstruction."	
Paved shoulder	See signage and education	**N/A**
Connected bikeway	See signage and education	**"Longitudinal pavement markings shall be used to define bicycle lanes."**
Connected bikeway Shared use path	"The BIKE LANE (R3-17) sign and the R3-17aP and R3-17bP plaques (see Figure 14) shall be used only in conjunction with marked bicycle lanes as described in Section 9C.04."	**"Shared-lane markings shall not be used on shoulders or in designated bicycle lanes."**
	"The BIKE LANE (R3-17) sign and the R3-17aP and R3-17bP plaques (see Figure 14) shall be used only in conjunction with marked bicycle lanes as described in Section 9C.04."	**"Markings used on bikeways shall be retroreflectorized**
	See signage and education	**"The colors, width of lines, patterns of lines, symbols, and arrows used for marking bicycle facilities shall be as defined in Sections 3A.05, 3A.06, and 3B.20."**
		See connected bikeway
Shared use path	See connected bikeway	**See connected bikeway**
	"Where used on a shared-use path, no portion of a sign or its support shall be placed less than 2 feet laterally from, or less than 8 feet vertically over the entire width of the shared-use path."	
	"Mounting height for post-mounted signs on shared-use paths shall be a minimum of 4 feet, measured vertically from the bottom of the sign to the elevation of the near edge of the path surface."	
	"The minimum sign and plaque sizes for shared-use paths shall be those shown in Table 9B-1, and shall be used only for signs and plaques installed specifically for bicycle traffic applications. The minimum sign and plaque sizes for bicycle facilities shall not be used for signs or plaques that are placed in a location that would have any application to other vehicles."	
	"Obstructions in the traveled way of a shared-use path shall be marked with retroreflectorized material or appropriate object markers."	
	"STOP (R1-1) signs shall be installed on shared-use paths at points where bicyclists are required to stop."	
	"YIELD (R1-2) signs shall be installed on shared-use paths at points where bicyclists have an adequate view of conflicting traffic as they approach the sign, and where bicyclists are required to yield the right-of-way to that conflicting traffic."	

APPENDIX X. ESTIMATING COSTS

Cost estimates for this project are very rough, and intended to give an approximation of what each alternative might come to. HWSP can make signs in-house, and can add symbols or striping to the pavement, so no costs were figured for either of these. The addition of pavement requires more technical considerations, specifically determining the area in cubic yards for the additional pavement. The AASHTO Manual gives guidance on considerations for determining the area, as seen in the following figure.



The team also consulted with Gus Smithhisler, the roadway maintenance program manager for the Division of Engineering with ODNR, for some guidance on obtaining reasonable estimate measurements. To figure the paving costs, the team took sample measurements along Main Loop Road at every mile, starting at Brown Road, heading west and stopping every mile based on the odometer (see map below for measurement locations). The measurements consist of potential widths (4 and 10 feet) parallel to the road as well as the drop from the roadway level to the existing surface level in the berm. The average of these measurements was multiplied by the length of the road to give a rough estimate of the materials required in cubic yards. The price per cubic yards is based on consulting with ODOT Estimator Jim Sparkes, who was also kind enough to provide the team with an estimate for widening the road 4 feet on either side for 8 miles. Mr. Sparkes used a simpler method for calculating the area,

essentially just calculating a rectangle. The team used these figures to make an approximate estimate for widening the road 10 feet, to accommodate a sidepath. Below is Mr. Sparkes' estimate:

Estimate for the bikeway based on adding two 4' wide bike lanes (one on each side) for eight miles. The thicknesses of the bike lanes match the existing roadway.

301E46000 Asphalt Concrete Base, PG64-22 (6") - 6,255 cy @ $115.00 cy

304E20000 Aggregate Base (6") - 6,255 cy @ $35.00 cy

407E10000 Tack Coat (.075 gal/sy) - 2,815 gal @ $2.00 gal

407E14000 Tack Coat for Intermediate Course (.04 gal/sy) - 1,500 gal @$2.00 gal

448E46050 Asphalt Concrete Intermediate Course, Type 2, PG64-22 (1-3/4") - 1,825 cy @$125.00 cy

448E46050 Asphalt Concrete Surface Course, Type 1, PG64-22 (1-1/2") - 1,565 cy @ $145.00 cy

204E10000 Subgrade Compaction - 37,545 sy @ $1.50 sy

203E10000 Excavation (Excavating for Bike Lanes) - 15,900 cy @ $10.00 cy

A barrier for a sidepath would need to be installed, below is an example and price for a set of 4. If the bollards are spaced 1 yard apart, the sidepath on Main Loop Road would require approximately 14,000 bollards. These bollards are flexible 360 degrees, and could withstand minor collisions with vehicles and allow snowplows to clear the road right up to the edge of the barrier without fear of damaging them. Below are a couple of options:

http://www.barcoproducts.com/products/barriers-barricades-and-crowd-control/bollards-and-bollard-covers/Spring-Back-Bollards.cfm

Model #	Model Name	Model Dimensions	Weight	Price
06AR1200	Case of four 43" spring-back bollards	8" dia. x 42.5" h	36 lbs	$428.85

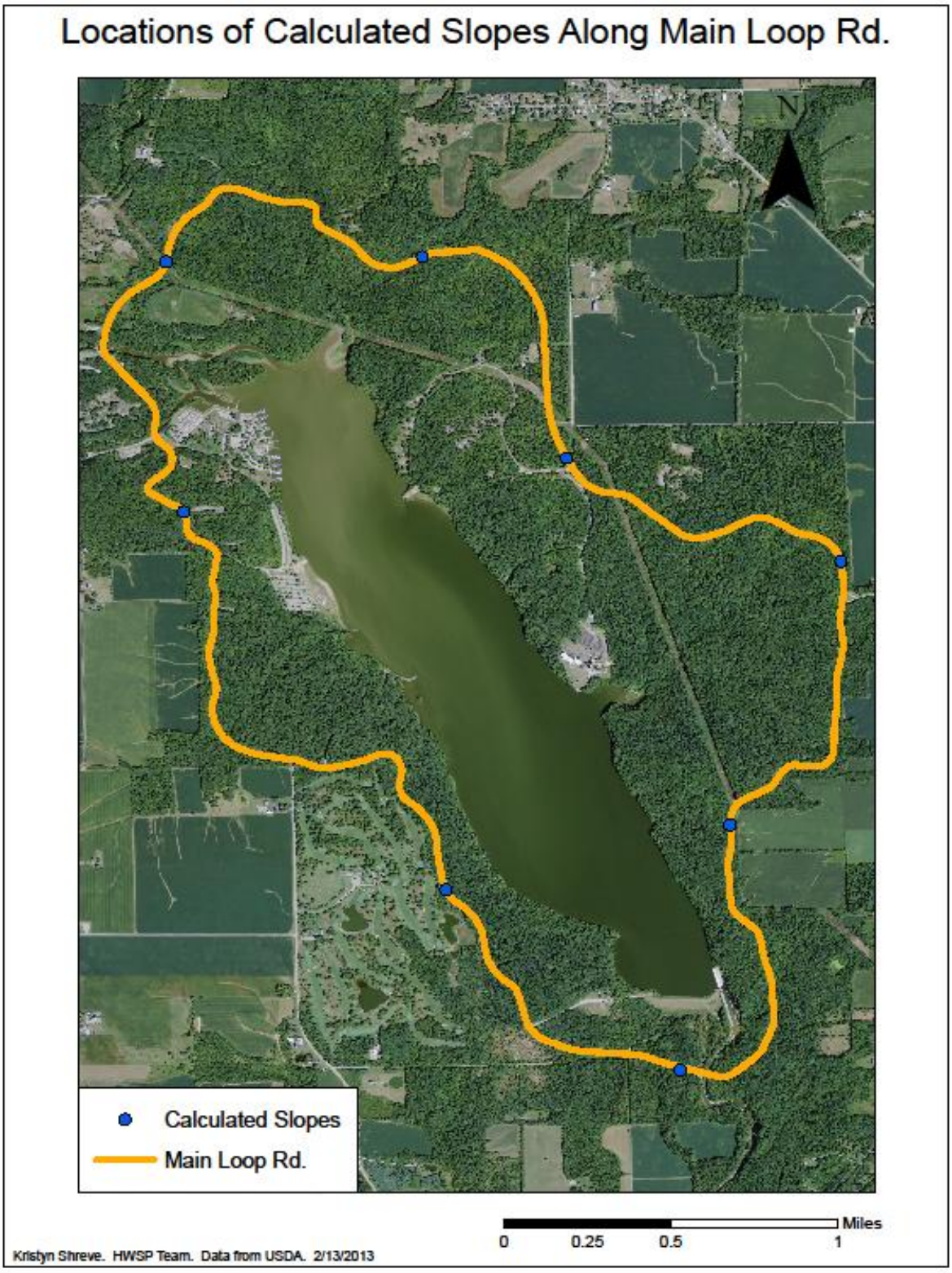
http://www.trafficsafetystore.com/delineator-posts/urethane-delineator-posts

36" Orange Poly-Urethane Delineator Post
Available with and without two 3" reflective stripes (collars).

Three Mounting Options to Choose From:

- Surface Mount with fasteners for asphalt or concrete
- Surface Mount with adhesive (bundy) pads
- Flush mount (requires a core driller for pavement)

36" Orange Post	$32.20 (quantities of 50+)


Locations of Calculated Slopes Along Main Loop Rd.
N
Calculated Slopes
Main Loop Rd.
Miles
0
0.25
0.5
1
Kristyn Shreve. HWSP Team. Data from USDA. 2/13/2013

APPENDIX Y. AMERICANS WITH DISABILITIES ACT GUIDELINES

COMPARISON OF AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) GUIDELINES FOR BICYCLE FACILITIES AND THE PROPOSED GUIDELINES FOR TRAILS (THE UNITED STATES, 2009)

Outdoor Developed Areas Accessibility Guidelines	AASHTO Guide for the Development of Bicycle Facilities, 1999
16.2.1 Surface: Firm and stable.	Bicycles need the same firmness and stability as wheelchairs; skaters usually require a smooth, paved surface. Most shared use paths are paved, although crushed aggregate surfaces are used on some paths.
16.2.2, Clear Tread Width: 36 inches (3 feet; 915 mm); exception for 32 inches (815 mm).	Shared use paths usually require a minimum 3 meter (10 foot) width, plus a 0.6 meter (2 foot) safety buffers on both sides. A 2.4 m (8 ft) width may be allowed in low use facilities. Posts or bollards installed to restrict motor vehicle traffic should be spaced 1.5 m (5 feet) apart. Posts or bollards should be brightly painted and reflectorized for visibility. When more than one post is used, use an odd number, with one on the centerline to help direct opposing traffic.
16.2.3, Surface Openings (Gaps): To prevent wheelchair wheels and cane tips from being caught in surface openings or gaps, openings in trail surfaces shall be of a size which does not permit passage of a ½ inch (13 mm) diameter sphere, elongated openings must be perpendicular or diagonal to the direction of travel; exception to permit parallel direction elongated openings if openings do not permit passage of a ¼ inch (6 mm) sphere; second exception to permit openings which do not permit passage of a ¾ inch (19 mm) sphere.[(1)]	The AASHTO Guide does not specify a maximum dimension for a surface opening, but openings should be minimized. Openings should not permit a bicycle wheel to enter.[(2)] Grates should be flush with the surface, and elongated openings should be perpendicular to the direction of travel. (Diagonal openings are more difficult for bicyclists to negotiate). Where openings are unavoidable, they should be clearly marked.
16.2.4, Protruding Objects: ADAAG 4.4; provide a warning if vertical clearance is less than 80 inches (2030 mm).	Protruding objects should not exist within the clear tread width of a shared use path. Vertical clearance on shared use paths should be a minimum of 3 m (10 feet) or the full clear width and the safety buffers. Where vertical barriers and obstructions, such as abutments, piers, and other features are unavoidable, they should be clearly marked.
16.2.5, Tread Obstacles (Changes in level, roots, rocks, ruts): Up to 2 inches (50 mm); exception up to 3 inches (75 mm).	Tread obstacles are hazardous to bicyclists and skaters. The surface of a shared use path should be smooth and should not have tread obstacles.

16.2.6, Passing Space: At least 60 inches (1525 mm) width within 1,000 foot (300 m) intervals. Appendix note recommends more frequent intervals for some trail segments.	Shared use paths should have a minimum clear width of 3 m (10 ft), exception for 2.4 m (8 ft).
16.2.7.1 Cross slope: 1:20 (5%) maximum; exceptions for open drains up to 1:10 (10%).	For drainage, shared use paths should have a minimum 2% (1:50) cross slope on a paved surface. On unpaved shared use paths, particular attention should be paid to drainage to avoid erosion. Curves on shared use paths may require super elevation beyond 2% (1:50) for safety reasons. The Guide suggests limited cross slope for accessibility reasons.
16.2.7.2 Running Slope: 1:20 (5%) any length 1:12 (8.33%) for up to 200 feet 1:10 (10%) for up to 30 feet 1:8 (12.5%) for up to 10 feet No more than 30% of the total trail length shall exceed 1:12	Running slopes on shared use paths should be kept to a minimum; grades greater than 5 percent are undesirable. Grades steeper than 3 percent may not be practical for shared use paths with crushed stone or other unpaved surfaces. Where terrain dictates, grade lengths are recommended as follows: < 5% (< 1:20) any length 5-6% (1:20-16.7) for up to 240 m (800 ft) 7% (1:14.3) for up to 120 m (400 ft) 8% (1:12.5) for up to 90 m (300 ft) 9% (1:11.1) for up to 60 m (200 ft) 10% (1:10) for up to 30 m (100 ft) 11+% (1:9.1) for up to 15 m (50 ft)
16.2.8, Resting Intervals: Size: 60 inch (1525 mm) length, at least as wide as the widest trail segment adjacent to the rest area. Less than 1:20 (5%) slope in any direction. Resting areas are required where trail running slopes exceed 1:20 (5%), at intervals no greater than the lengths permitted under running slope (see 16.2.7.2 above).	The Guide does not address resting intervals.
16.2.9, Edge protection: Where provided, 3 inch (75 mm) minimum height. Handrails are not required.	The Guide does not address edge protection. Some kinds of edge protection may be hazardous to bicyclists and skaters. The Guide has minimum railing height recommendations when needed for safety reasons.
16.2.10, Signs: Accessible trails require designation with a symbol of accessibility, and information on total length of the accessible segment.	Guidance on signing and marking is provided in the Manual on Uniform Traffic Control Devices (MUTCD), incorporated by reference as a Federal regulation (23 CFR 655.601). A

No traffic control sign information.	proposed amendment for Part 9 (Traffic Controls for Bicycle Facilities) was published in the Federal Register on June 24, 1999 (64 FR 33802-33806). A rulemaking is scheduled for March 2000 that will have an update for Part 4 (Signals), that will include provisions for pedestrian signals for people with disabilities.
Source	Definition: Shared Use Path
AASHTO Bicycle Facilities Guide http://design.transportation.org/Documents/DraftBikeGuideFeb2010.pdf	A BIKEWAY PHYSICALLY SEPARATED FROM MOTORIZED VEHICULAR TRAFFIC BY AN OPEN SPACE OR BARRIER AND EITHER WITHIN THE HIGHWAY RIGHT-OF-WAY OR WITHIN AN INDEPENDENT RIGHT-OF-WAY. SHARED USE PATHS MAY ALSO BE USED BY PEDESTRIANS, SKATERS, WHEELCHAIR USERS, JOGGERS, AND OTHER NONMOTORIZED USERS.
U.S. Department of Transportation, Federal Highway Administration http://www.fhwa.dot.gov/environment/bikeped/freeways.htm	THE TERM "SHARED USE PATH" MEANS A MULTI-USE TRAIL OR OTHER PATH, PHYSICALLY SEPARATED FROM MOTORIZED VEHICULAR TRAFFIC BY AN OPEN SPACE OR BARRIER, EITHER WITHIN A HIGHWAY RIGHT-OF-WAY OR WITHIN AN INDEPENDENT RIGHT-OF-WAY, AND USABLE FOR TRANSPORTATION PURPOSES. SHARED USE PATHS MAY BE USED BY PEDESTRIANS, BICYCLISTS, SKATERS, EQUESTRIANS, AND OTHER NONMOTORIZED USERS.
State of Washington, Department of Transportation http://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm	A FACILITY PHYSICALLY SEPARATED FROM MOTORIZED VEHICULAR TRAFFIC WITHIN THE HIGHWAY RIGHT-OF-WAY OR ON AN EXCLUSIVE RIGHT OF WAY WITH MINIMAL CROSSFLOW BY MOTOR VEHICLES. PRIMARILY USED BY PEDESTRIANS AND BICYCLISTS, SHARED USE PATHS ARE ALSO USED BY JOGGERS, SKATERS, WHEELCHAIR USERS (BOTH NONMOTORIZED AND MOTORIZED), EQUESTRIANS, AND OTHER NONMOTORIZED USERS.

APPENDIX Z. LOCAL BIKEWAYS AND POTENTIAL CONNECTIONS

The scope of this study is within the boundaries of HWSP, but in consideration of other local bikeways, it is necessary to inventory potential connections to the park.

There are currently three existing or planned trails within Butler or Preble County, where HWSP is located. These trails are the Great Miami River Recreation Trail, the Miami 2 Miami Connection, and the Oxford Perimeter Path.

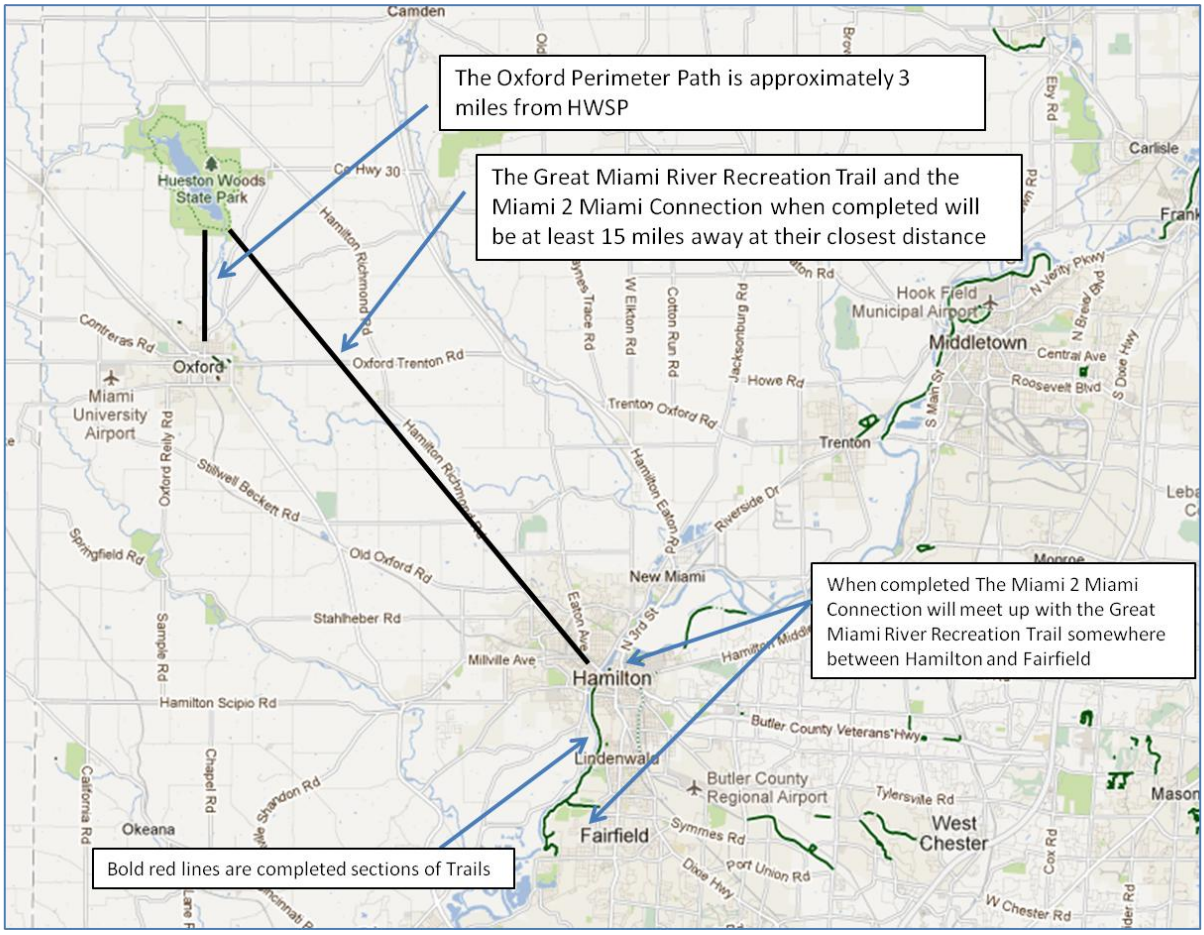
The Great Miami River Recreation Trail runs from Sidney to Fairfield through Shelby, Miami, Montgomery, and Butler County. Sixty-four miles of the trail are currently finished with ninety-five planned at completion (Ohio Kentucky Indiana Regional Council of Governments 2011).

The Miami 2 Miami Connection is a proposed eighty-four mile trail to connect the Great Miami River Recreation Trail at Hamilton to the Little Miami Scenic Trail at Kings Mills. Both the Great Miami River Recreation Trail and the Miami 2 Miami Connection would be more than fifteen miles from HWSP at their closest and so do not present an immediate opportunity for a connecting trail (Barge et al. 2002).

The Oxford Perimeter Path is only three miles from HWSP, but only one mile of the proposed ten mile loop is currently completed. The Oxford Perimeter Path may have the potential for a connecting bikeway to HWSP in the future (Ohio Kentucky Indiana Regional Council of Governments 2011).

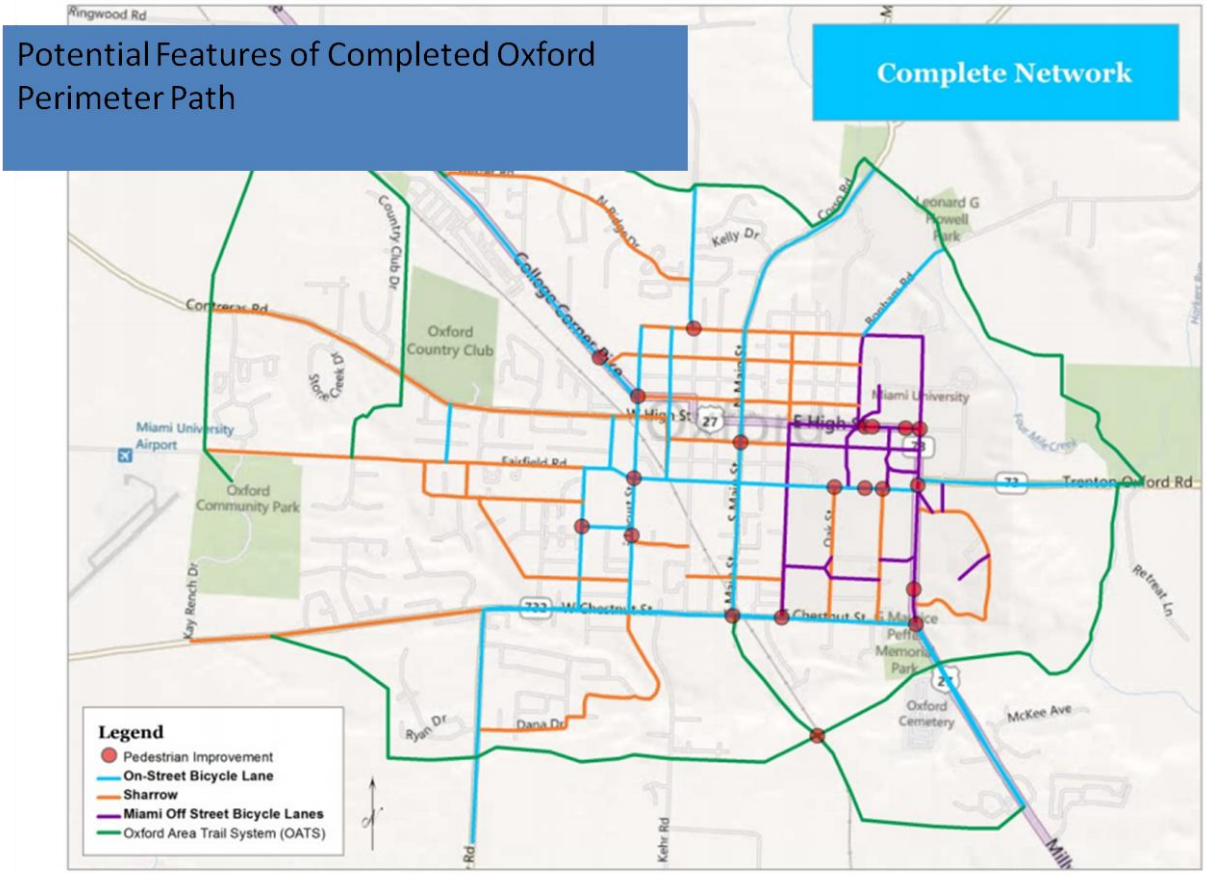
The agency most likely able to implement such a bikeway in the future is Metroparks of Butler County. Metroparks is a board of commissioners appointed to oversee county park system decisions. When asked about potential connecting paths from Oxford to HWSP a Metroparks representative stated that, "At this point in time, MetroParks does not have specific plans in place for development of the property north of Oxford. This property is being acquired with Clean Ohio Conservation Funds, and all future development of the property must comply with the use and development restrictions associated with this funding. Like any other MetroParks' property, a Master Planning process, with community input, would need to occur prior to development, to determine the way in which that property would be best used to match park customer's desired uses while complying with any restrictions. Until the property is purchased and Master Planning is complete, it would be premature to speculate relative to any use of this land at this time." (Personal Correspondence was with Cristy Trammell of Metroparks of Butler County).

Distance of Planned and Completed Local Trails from HWSP



Original Map courtesy of Ohio Bike Way

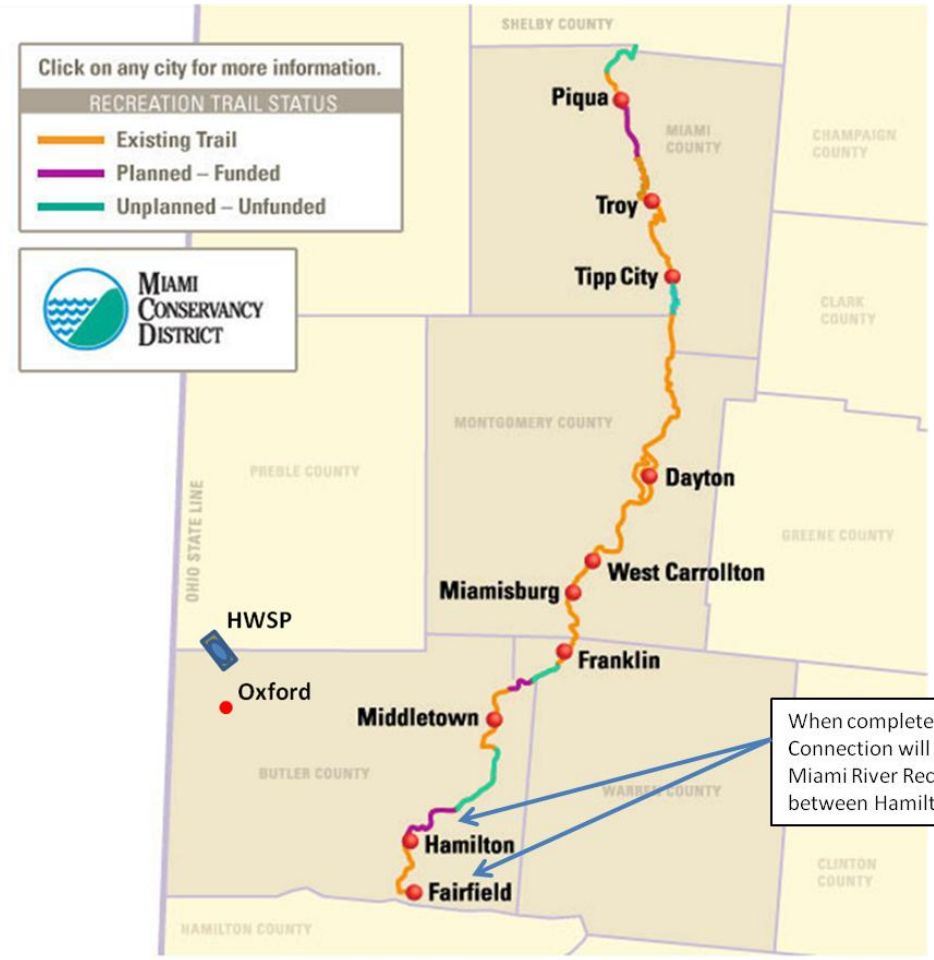
http//www.ohiobikeways.net/gmap.htm



"Map illustrating recommended long range plan for bicycle and pedestrian improvements in Oxford"

Shifting Gears: A Bicycle and Pedestrian Plan for Oxford, Ohio
Dragovich, Anna Louise. 2012

Great Miami River Recreation Trail



Original Map courtesy of Drive Less Live More

http://drivelesslivemmore.org/6_plantrip.html